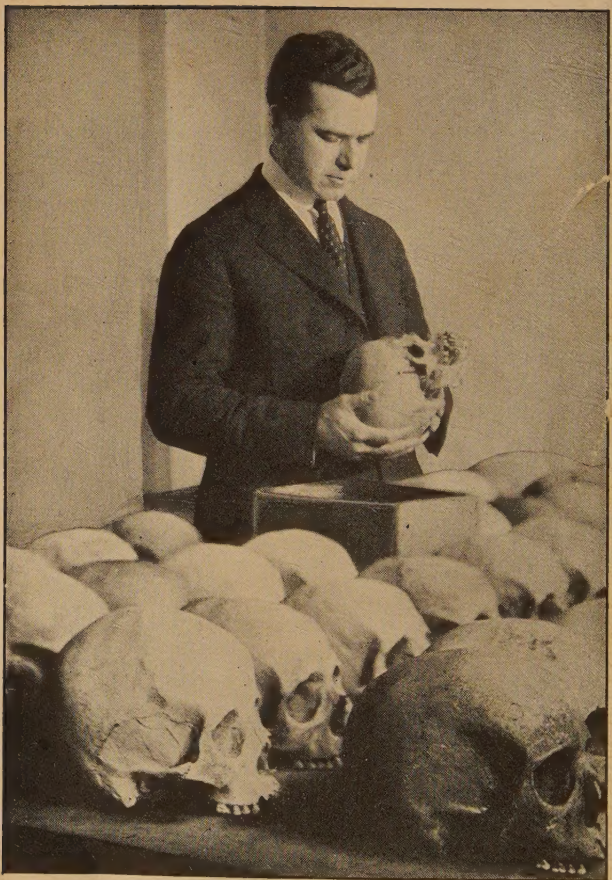

SKULLS AT THE LONDON ANTHROPOLOGICAL INSTITUTE

THE STORY OF MODERN SCIENCE

By
HENRY SMITH WILLIAMS

IN TEN VOLUMES
ILLUSTRATED

VOLUME X

MAN AND THE MAGIC OF MEDICINE

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PREFATORY NOTE

Two articles that I originally wrote for the *Encyclopaedia Britannica* are reproduced in the present volume, to form the bulk of Chapters IV and VI. The article here called "Archeology and the Scope of History" was first published (except the concluding portion on pre-history, which is new) as an introductory essay in the tenth edition of the *Britannica,* and reproduced in part in the eleventh edition under the heading "Chronology." The chapter called "Science and Civilization" first appeared as the article "Civilization" in the eleventh edition of the *Encyclopaedia Britannica,* and is reproduced here unchanged, but with the addition of the concluding matter following the sub-head "Looking Forward" on page 191.

The two articles were thus given wide publicity in 1903 and 1910, respectively. I mention the dates in particular because my attention has been called to at least one instance in which a paraphrased but unmistakable quotation is made without credit from one of the articles, in a recently published popular book. I have no objection to such use of anything I have published here or elsewhere (I am mindful, too, that many writers

regard matter published in an encyclopaedia as common property), but the sedulous crediting of authorities is so inherent a feature of my own code of composition, that I should regret exceedingly to have it thought in this or any similar case that I had been the borrower.

To minimize the probability of such misinterpretation, I would call attention here to the announcement made in the General Introduction in Volume I of this series, telling that in the preparation of these volumes I have drawn freely upon my earlier publications. My chief reason for adding this supplementary notice here, however, is to credit the *Encyclopaedia Britannica* with the articles just mentioned, and to express my appreciation of the courtesy through which I am permitted to reproduce them in the present connection.

HENRY SMITH WILLIAMS.

Grand Central Terminal,
New York City,
April 16th, 1923.

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The Story
of
Modern Science

VOLUME X

MAN AND THE MAGIC OF MEDICINE

MAN AND THE MAGIC OF MEDICINE

CHAPTER I

THE RISE OF MODERN MEDICINE

JENNER AND VACCINATION

ALL advances in science have a bearing, near or remote, on the welfare of our race; but it remains to credit to the closing decade of the eighteenth century a discovery which, in its power of direct and immediate benefit to humanity, surpasses any other discovery of this or any previous epoch. Needless to say, I refer to Jenner's discovery of the method of preventing small-pox by inoculation with the virus of cow-pox.

It detracts nothing from the merit of this discovery to say that the preventive power of accidental inoculation had long been rumored among the peasantry of England. Such vague, unavailing half-knowledge is often the forerunner of fruitful discovery.

To all intents and purposes Jenner's discovery was original and unique. Nor, considered as a perfect method, was it in any sense an accident. It was a triumph of experimental science. The discoverer was no novice in scientific investigation, but a trained observer, who had served a long apprenticeship in scientific observation under no less a scientist than the celebrated John Hunter.

At the age of twenty-one Jenner had gone to London to pursue his medical studies, and soon after he proved himself so worthy a pupil that for two years he remained a member of Hunter's household as his favorite pupil. His taste for science and natural history soon attracted the attention of Sir Joseph Banks, who intrusted him with the preparation of the zoological specimens brought back by Captain Cook's expedition in 1771. He performed this task so well that he was offered the position of naturalist to the second expedition, but declined it, preferring to take up the practice of his profession in his native town of Berkeley.

His many accomplishments and genial personality soon made him a favorite both as a physician and in society. He was a good singer, a fair violinist and flute-player, and a very successful writer of prose and verse. But with all his professional and social duties he still kept up his scientific investigations, among other things making some careful observations on the hibernation of hedgehogs at the instigation of Hunter, the results of which were laid before the Royal Society. He also made quite extensive investigations as to the geological formations and fossils found in his neighborhood.

Even during his student days with Hunter he had been much interested in the belief, current in the rural districts of Gloucestershire, of the antagonism between cow-pox and small-pox, a person having suffered from cow-pox being immune to small-pox. At various times Jenner had mentioned the subject to Hunter, and he was constantly making inquiries of his fellow-prac-

titioners as to their observations and opinions on the subject. Hunter was too fully engrossed in other pursuits to give the matter much serious attention, however, and Jenner's brothers of the profession gave scant credence to the rumors, altho such rumors were common enough.

At this time the practice of inoculation for preventing small-pox, or rather averting the severer forms of the disease, was widely practised. It was customary, when there was a mild case of the disease, to take some of the virus from the patient and inoculate persons who had never had the disease, producing a similar attack in them. Unfortunately there were many objections to this practise. The inoculated patient frequently developed a virulent form of the disease and died; or if he recovered, even after a mild attack, he was likely to be "pitted" and disfigured. But, perhaps worst of all, a patient so inoculated became the source of infection to others, and it sometimes happened that disastrous epidemics were thus brought about. The case was a most perplexing one, for the awful scourge of small-pox hung perpetually over the head of every person who had not already suffered and recovered from it. The practice of inoculation was introduced into England by Lady Mary Wortley Montague (1690-1762), who had seen it practised in the East, and who announced her intention of "introducing it into England in spite of the doctors."

From the fact that certain persons, usually milk-maids, who had suffered from cow-pox seemed to be immune to small-pox, it would seem a very simple process of deduction to discover that cow-

pox inoculation was the solution of the problem of preventing the disease. But there was another form of disease which, while closely resembling cow-pox and quite generally confounded with it, did not produce immunity. The confusion of these two forms of the disease had constantly misled investigations as to the possibility of either of them immunizing against small-pox, and the difficulties of unequivocal diagnosis for a time led Jenner to question the possibility of doing so. After careful investigations, however, he reached the conclusion that there was a difference in the effects of the two diseases, only one of which produced immunity from small-pox.

In 1796 Jenner made his first inoculation with cow-pox matter, and two months later the same subject was inoculated with small-pox matter. But, as Jenner had predicted, no attack of small-pox followed. Altho fully convinced by this experiment that the case was conclusively proven, he continued his investigations, waiting two years before publishing his discovery. Then, fortified by indisputable proofs, he gave it to the world. The immediate effects of his announcement have probably never been equaled in the history of scientific discovery, unless, perhaps, in the single instance of the discovery of anesthesia. In Geneva and Holland clergymen advocated the practise of vaccination from their pulpits; in some of the Latin countries religious processions were formed for receiving vaccination; Jenner's birthday was celebrated as a feast in Germany; and the first child vaccinated in Russia was named "Vaccinov" and educated at public expense. In six years the discovery had penetrated to the most remote cor-

ners of civilization; it had even reached some savage nations. And in a few years small-pox had fallen from the position of the most dreaded of all diseases to that of being practically the only disease for which a sure and easy preventive was known.

Honors were showered upon Jenner from the Old and the New World, and even Napoleon, the bitter hater of the English, was among the others who honored his name. On one occasion Jenner applied to the Emperor for the release of certain Englishmen detained in France. The petition was about to be rejected when the name of the petitioner was mentioned. "Ah," said Napoleon, "we can refuse nothing to that name!"

It is difficult for us of to-day clearly to conceive the greatness of Jenner's triumph, for we can only vaguely realize what a ruthless and ever-present scourge small-pox had been to all previous generations of men since history began. Despite all efforts to check it by medication and by direct inoculation, it swept now and then over the earth as an all-devastating pestilence, and year by year it claimed one-tenth of all the beings in Christendom by death as its average quota of victims. "From small-pox and love but few remain free," ran the old saw. A pitted face was almost as much a matter of course in the eighteenth century as a smooth one is to-day.

Little wonder, then, that the world gave eager acceptance to Jenner's discovery. No urging was needed to induce the majority to give it trial; passengers on a burning ship do not hold aloof from the life-boats. Rich and poor, high and low, sought succor in vaccination and blessed the name

of their deliverer. Of all the great names that were before the world in the closing days of the century, there was perhaps no other one at once so widely known and so uniformly reverenced as that of the great English physician Edward Jenner. Surely there was no other one that should be recalled with greater gratitude by posterity.

PHYSICAL DIAGNOSIS

Altho Napoleon Bonaparte, First Consul, was not lacking in self-appreciation, he probably did not realize that in selecting a physician for his own needs he was markedly influencing the progress of medical science as a whole. Yet so strangely are cause and effect adjusted in human affairs that this simple act of the First Consul had that very unexpected effect. For the man chosen was the envoy of a new method in medical practise, and the fame which came to him through being physician to the First Consul, and subsequently to the Emperor, enabled him to promulgate the method in a way otherwise impracticable. Hence the indirect but telling value to medical science of Napoleon's selection.

The physician in question was Jean Nicolas de Corvisart. His novel method was nothing more startling than the now familiar procedure of tapping the chest of a patient to elicit sounds indicative of diseased tissues within. Every one has seen this done commonly enough in our day, but at the beginning of the century Corvisart, and perhaps some of his pupils, were probably the only physicians in the world who resorted to this simple and useful procedure. Hence Napoleon's

surprize when, on calling in Corvisart, after becoming somewhat dissatisfied with his other physicians Pinel and Portal, his physical condition was interrogated in this strange manner. With characteristic shrewdness Bonaparte saw the utility of the method, and the physician who thus attempted to substitute scientific method for guesswork in the diagnosis of disease at once found favor in his eyes and was installed as his regular medical adviser.

For fifteen years before this Corvisart had practised percussion, as the chest-tapping method is called, without succeeding in convincing the profession of its value. The method itself, it should be added, had not originated with Corvisart, nor did the French physician for a moment claim it as his own. The true originator of the practise was the German physician Avenbrugger, who published a book about it as early as 1761. This book had even been translated into French, then the language of international communication everywhere, by Rozière de la Chassagne, of Montpellier, in 1770; but no one other than Corvisart appears to have paid any attention to either original or translation. It was far otherwise, however, when Corvisart translated Avenbrugger's work anew, with important additions of his own, in 1808.

"I know very well how little reputation is allotted to translator and commentators," writes Corvisart, "and I might easily have elevated myself to the rank of an author if I had elaborated anew the doctrine of Avenbrugger and published an independent work on percussion. In this way, however, I should have sacrificed the name of

Avenbrugger to my own vanity, a thing which I am unwilling to do. It is he, and the beautiful invention which of right belongs to him, that I desire to recall to life."

By this time a reaction had set in against the metaphysical methods in medicine that had previously been so alluring; the scientific spirit of the time was making itself felt in medical practice; and this, combined with Corvisart's fame, brought the method of percussion into immediate and well-deserved popularity. Thus was laid the foundation for the method of so-called physical diagnosis, which is one of the corner-stones of modern medicine.

The method of physical diagnosis as practised in our day was by no means completed, however, with the work of Corvisart. Percussion alone tells much less than half the story that may be elicited from the organs of the chest by proper interrogation. The remainder of the story can only be learned by applying the ear itself to the chest, directly or indirectly. Simple as this seems, no one thought of practising it for some years after Corvisart had shown the value of percussion.

Then, in 1815, another Paris physician, René Théophile Hyacinthe Laënnec, discovered, almost by accident, that the sound of the heart-beat could be heard surprizingly through a cylinder of paper held to the ear and against the patient's chest. Acting on the hint thus received, Laënnec substituted a hollow cylinder of wood for the paper, and found himself provided with an instrument through which not merely heart sounds but murmurs of the lungs in respiration could be heard with almost startling distinctness.

The possibility of associating the varying chest sounds with diseased conditions of the organs within appealed to the fertile mind of Laënnec as opening new vistas in therapeutics, which he determined to enter to the fullest extent practicable. His connection with the hospitals of Paris gave him full opportunity in this direction, and his labors of the next few years served not merely to establish the value of the new method as an aid to diagnosis, but laid the foundation also for the science of morbid anatomy. In 1819 Laënnec published the results of his labors in a work called *Traité d'Auscultation Médiate,* a work which forms one of the landmarks of scientific medicine. By mediate auscultation is meant, of course, the interrogation of the chest with the aid of the little instrument already referred to, an instrument which its originator thought hardly worth naming until various barbarous appellations were applied to it by others, after which Laënnec decided to call it the stethoscope, a name which it has ever since retained.

In subsequent years the form of the stethoscope, as usually employed, was modified and its value augmented by a binauricular attachment, and in very recent years a further improvement has been made through application of the principle of the telephone; but the essentials of auscultation with the stethoscope were established in much detail by Laënnec, and the honor must always be his of thus taking one of the longest single steps by which practical medicine has in our century acquired the right to be considered a rational science. Laënnec's efforts cost him his life, for he died in 1826 of a lung disease acquired

in the course of his hospital practise; but even before this his fame was universal, and the value of his method had been recognized all over the world. Not long after, in 1828, yet another French physician, Piorry, perfected the method of percussion by introducing the custom of tapping, not the chest directly, but the finger or a small metal or hard-rubber plate held against the chest—mediate percussion, in short. This perfected the methods of physical diagnosis of diseases of the chest in all essentials; and from that day till this percussion and auscultation have held an unquestioned place in the regular armamentarium of the physician.

Coupled with the new method of physical diagnosis in the effort to substitute knowledge for guesswork came the studies of the experimental physiologists—in particular, Marshall Hall in England and François Magendie in France; and the joint efforts of these various workers led presently to the abandonment of those severe and often irrational depletive methods—blood-letting and the like—that had previously dominated medical practise. To this end also the "statistical method," introduced by Louis and his followers, largely contributed; and by the close of the first third of our century the idea was gaining ground that the province of therapeutics is to aid nature in combating disease, and that this may often be accomplished better by simple means than by the heroic measures hitherto thought necessary. In a word, scientific empiricism was beginning to gain a hearing in medicine as against the metaphysical preconceptions of the earlier generations.

PARASITIC DISEASE

I have just adverted to the fact that Napoleon Bonaparte, as First Consul and as Emperor, was the victim of a malady which caused him to seek the advice of the most distinguished physicians of Paris. It is a little shocking to modern sensibilities to read that these physicians, except Corvisart, diagnosed the distinguished patient's malady as "*gale répercutée*"—that is to say, in idiomatic English, the itch "struck in." It is hardly necessary to say that no physician of to-day would make so inconsiderate a diagnosis in the case of a royal patient.

If by any chance a distinguished patient was afflicted with the itch, the sagacious physician would carefully hide the fact behind circumlocutions and proceed to eradicate the disease with all dispatch.

That the physicians of Napoleon did otherwise is evidence that at the beginning of the century the disease in question enjoyed a very different status. At that time itch, instead of being a most plebeian malady, was, so to say, a court disease. It enjoyed a circulation, in high circles and in low, that modern therapeutics has quite denied it; and the physicians of the time gave it a fictitious added importance by ascribing to its influence the existence of almost any obscure malady that came under their observation.

Long after Napoleon's time *gale* continued to hold this proud distinction. For example, the imaginative Dr. Hahnemann did not hesitate to affirm, as a positive maxim, that three-fourths of all the ills that flesh is heir to were in reality nothing but various forms of "*gale répercutée.*"

All of which goes to show how easy it may be for a masked pretender to impose on credulous humanity, for nothing is more clearly established in modern knowledge than the fact that "*gale répercutée*" was simply a name to hide a profound ignorance; no such disease exists or ever did exist. *Gale* itself is a sufficiently tangible reality, to be sure, but it is a purely local disease of the skin, due to a perfectly definite cause, and the dire internal conditions formerly ascribed to it have really no causal connection with it whatever.

This definite cause, as every one nowadays knows, is nothing more or less than a microscopic insect which has found lodgment on the skin, and has burrowed and made itself at home there. Kill that insect and the disease is no more; hence it has come to be an axiom with the modern physician that the itch is one of the three or four diseases that he positively is able to cure, and that very speedily. But it was far otherwise with the physicians of the early nineteenth century, because to them the cause of the disease was an absolute mystery.

It is true that here and there a physician had claimed to find an insect lodged in the skin of a sufferer from itch, and two or three times the claim had been made that this was the cause of the malady, but such views were quite ignored by the general profession, and in 1833 it was stated in an authoritative medical treatise that the "cause of *gale* is absolutely unknown." But even at this time, as it curiously happened, there were certain ignorant laymen who had attained to a bit of medical knowledge that was withheld from the inner circles of the profession.

As the peasantry of England before Jenner had known of the curative value of cow-pox over small-pox, so the peasant women of Poland had learned that the annoying skin disease from which they suffered was caused by an almost invisible insect, and, furthermore, had acquired the trick of dislodging the pestiferous little creature with the point of a needle. From them a youth of the country, F. Renucci by name, learned the open secret. He conveyed it to Paris when he went there to study medicine, and in 1834 demonstrated it to his master Alibert. This physician, at first skeptical, soon was convinced, and gave out the discovery to the medical world with an authority that led to early acceptance.

Now the importance of all this, in the present connection, is not at all that it gave the clue to the method of cure of a single disease. What makes the discovery epochal is the fact that it dropped a brand-new idea into the medical ranks—an idea destined, in the long-run, to prove itself a veritable bomb—the idea, namely, that a minute and quite unsuspected animal parasite may be the cause of a well-known, widely prevalent, and important human disease.

Of course the full force of this idea could only be appreciated in the light of later knowledge; but even at the time of its coming it sufficed to give a great impetus to that new medical knowledge, based on microscopical studies, which had but recently been made accessible by the inventions of the lens-makers. The new knowledge clarified one very turbid medical pool and pointed the way to the clarification of many others.

Almost at the same time that the Polish medi-

cal student was demonstrating the itch mite in Paris, it chanced, curiously enough, that another medical student, this time an Englishman, made an analogous discovery of perhaps even greater importance. Indeed, this English discovery in its initial stages slightly antedated the other, for it was in 1833 that the student in question, James Paget, interne in St. Bartholomew's Hospital, London, while dissecting the muscular tissues of a human subject, found little specks of extraneous matter, which, when taken to the professor of comparative anatomy, Richard Owen, were ascertained, with the aid of the microscope, to be the cocoons of a minute and hitherto unknown insect.

Owen named the insect *Trichina spiralis*. After the discovery was published it transpired that similar specks had been observed by several earlier investigators, but no one had previously suspected or, at any rate, demonstrated their nature. Nor was the full story of the trichina made out for a long time after Owen's discovery.

It was not till 1847 that the American anatomist Dr. Joseph Leidy found the cysts of trichina in the tissues of pork; and another decade or so elapsed after that before German workers, chief among whom were Leuckart, Virchow, and Zenker, proved that the parasite gets into the human system through ingestion of infected pork, and that it causes a definite set of symptoms of disease which hitherto had been mistaken for rheumatism, typhoid fever, and other maladies. Then the medical world was agog for a time over the subject of trichinosis; government inspection of pork was established in some parts of Germany; American pork was excluded altogether from France;

and the whole subject thus came prominently to public attention. But important as the trichina parasite proved on its own account in the end, its greatest importance, after all, was in the share it played in directing attention at the time of its discovery in 1833 to the subject of microscopic parasites in general.

The decade that followed that discovery was a time of great activity in the study of microscopic organisms and microscopic tissues, and such men as Ehrenberg and Henle and Bory Saint-Vincent and Kölliker and Rokitansky and Remak and Dujardin were widening the bounds of knowledge of this new subject with details that can not be more than referred to here. But the crowning achievement of the period in this direction was the discovery made by the German, J. L. Schoenlein, in 1839, that a very common and most distressing disease of the scalp, known as favus, is really due to the presence and growth on the scalp of a vegetable organism of microscopic size.

Thus it was made clear that not merely animal but also vegetable organisms of obscure, microscopic species have causal relations to the diseases with which mankind is afflicted. This knowledge of the parasites was another long step in the direction of scientific medical knowledge; but the heights to which this knowledge led were not to be scaled, or even recognized, until another generation of workers had entered the field.

PAINLESS SURGERY

Meantime, in quite another field of medicine, events were developing which led presently to a revelation of greater immediate importance to

humanity than any other discovery that had come in the century, perhaps in any field of science whatever. This was the discovery of the pain-dispelling power of the vapor of sulfuric ether inhaled by a patient undergoing a surgical operation. This discovery came solely out of America, and it stands curiously isolated, since apparently no minds in any other country were trending towards it even vaguely. Davy, in England, had indeed originated the method of medication by inhalation, and carried out some most interesting experiments fifty years earlier, and it was doubtless his experiments with nitrous oxide gas that gave the clue to one of the American investigators; but this was the sole contribution of preceding generations to the subject, and since the beginning of the century, when Davy turned his attention to other matters, no one had made the slightest advance along the same line until an American dentist renewed the investigation.

From Davy's account it is evident that he anesthetized himself to a point where consciousness of surroundings was lost, but not past the stage of exhilaration. He appears to have realized that sensibility was dulled, for he adds this illuminative suggestion: "As nitrous oxid in its extensive operation appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place."

Unfortunately no one took advantage of this suggestion at the time, and Davy himself became interested in other fields of science and never returned to his physiological studies, thus barely missing one of the greatest discoveries in the en-

tire field of science. In the generation that followed no one seems to have thought of putting Davy's suggestion to the test, and the surgeons of Europe had acknowledged with one accord that all hope of finding a means to render operations painless must be utterly abandoned—that the surgeon's knife must ever remain a synonym for slow and indescribable torture. By an odd coincidence it chanced that Sir Benjamin Brodie, the acknowledged leader of English surgeons, had publicly expressed this as his deliberate tho regretted opinion at a time when the quest which he considered futile had already led to the most brilliant success in America, and while the announcement of the discovery, which then had no transatlantic cable to convey it, was actually on its way to the Old World.

The American dentist just referred to, who was, with one exception to be noted presently, the first man in the world to conceive that the administration of a definite drug might render a surgical operation painless and to give the belief application, was Dr. Horace Wells, of Hartford, Connecticut. The drug with which he experimented was nitrous oxid—the same that Davy had used; the operation that he rendered painless was no more important than the extraction of a tooth—yet it sufficed to mark a principle; the year of the experiment was 1844.

The experiments of Dr. Wells, however, tho important, were not sufficiently demonstrative to bring the matter prominently to the attention of the medical world. The drug with which he experimented proved not always reliable, and he himself seems ultimately to have given the matter

up, or at least to have relaxed his efforts. But meantime a friend, to whom he had communicated his belief and expectations, took the matter up, and with unremitting zeal carried forward experiments that were destined to lead to more tangible results. This friend was another dentist, Dr. W. T. G. Morton, of Boston, then a young man full of youthful energy and enthusiasm. He seems to have felt that the drug with which Wells had experimented was not the most practicable one for the purpose, and so for several months he experimented with other allied drugs, until finally he hit upon sulfuric ether, and with this was able to make experiments upon animals, and then upon patients in the dental chair, that seemed to him absolutely demonstrative.

Full of eager enthusiam, and absolutely confident of his results, he at once went to Dr. J. C. Warren, one of the foremost surgeons of Boston, and asked permission to test his discovery decisively on one of the patients at the Boston Hospital during a severe operation. The request was granted; the test was made on October 16, 1846, in the presence of several of the foremost surgeons of the city and of a body of medical students. The patient slept quietly while the surgeon's knife was plied, and awoke to astonished comprehension that the ordeal was over. The impossible, the miraculous, had been accomplished.

Swiftly as steam could carry it—slowly enough we should think it to-day—the news was heralded to all the world. It was received in Europe with incredulity, which vanished before repeated experiments. Surgeons were loath to believe that ether, a drug that had long held a place in the

subordinate armamentarium of the physician, could accomplish such a miracle. But skepticism vanished before the tests which any surgeon might make, and which surgeons all over the world did make within the next few weeks. Then there came a lingering outcry from a few surgeons, notably some of the Parisians, that the shock of pain was beneficial to the patient, hence that anesthesia—as Dr. Oliver Wendell Holmes had christened the new method—was a procedure not to be advised. Then, too, there came a hue-and-cry from many a pulpit that pain was God-given, and hence, on moral grounds, to be clung to rather than renounced. But the outcry of the antediluvians of both hospital and pulpit quickly received its quietus; for soon it was clear that the patient who did not suffer the shock of pain during an operation rallied better than the one who did so suffer, while all humanity outside the pulpit cried shame to the spirit that would doom mankind to suffer needless agony. And so within a few months after that initial operation at the Boston Hospital in 1846, ether had made good its conquest of pain throughout the civilized world. Only by the most active use of the imagination can we of this present day realize the full meaning of that victory.

It remains to be added that in the subsequent bickerings over the discovery—such bickerings as follow every great advance—two other names came into prominent notice as sharers in the glory of the new method. Both these were Americans—the one, Dr. Charles T. Jackson, of Boston; the other, Dr. Crawford W. Long, of Alabama. As to Dr. Jackson, it is sufficient to say that he seems

to have had some vague inkling of the peculiar properties of ether before Morton's discovery. He even suggested the use of this drug to Morton, not knowing that Morton had already tried it; but this is the full measure of his association with the discovery. Hence it is clear that Jackson's claim to equal share with Morton in the discovery was unwarranted, not to say absurd.

Dr. Long's association with the matter was far different and altogether honorable. By one of those coincidences so common in the history of discovery, he was experimenting with ether as a pain-destroyer simultaneously with Morton, tho neither so much as knew of the existence of the other. While a medical student he had once inhaled ether for the intoxicant effects, as other medical students were wont to do, and when partially under influence of the drug he had noticed that a chance blow to his shins was painless. This gave him the idea that ether might be used in surgical operations; and in subsequent years, in the course of his practise in a small Georgia town, he put the idea into successful execution.

There appears to be no doubt whatever that he performed successful minor operations under ether some two or three years before Morton's final demonstration; hence that the merit of first using the drug, or indeed any drug, in this way belongs to him.

But, unfortunately, Dr. Long did not quite trust the evidence of his own experiments. Just at that time the medical journals were full of accounts of experiments in which painless operations were said to be performed through practise of hypnotism, and Dr. Long feared that his own success

might be due to an incidental hypnotic influence rather than to the drug. Hence he delayed announcing his apparent discovery until he should have opportunity for further tests—and opportunities did not come every day to the country practitioner. And while he waited, Morton anticipated him, and the discovery was made known to the world without his aid.

It was a true scientific caution that actuated Dr. Long to this delay, but the caution cost him the credit, which might otherwise have been his, of giving to the world one of the greatest blessings—dare we not, perhaps, say the very greatest?—that science has ever conferred upon humanity.

A few months after the use of ether became general, the Scotch surgeon Sir J. Y. Simpson discovered that another drug, chloroform, could be administered with similar effects; that it would, indeed, in many cases produce anesthesia more advantageously even than ether.

From that day to this surgeons have been more or less divided in opinion as to the relative merits of the two drugs; but this fact, of course, has no bearing whatever upon the merit of the first discovery of the method of anesthesia. Even had some other drug subsequently quite banished ether, the honor of the discovery of the beneficent method of anesthesia would have been in no wise invalidated. And despite all cavilings, it is unequivocally established that the man who gave that method to the world was William T. G. Morton.

PASTEUR AND THE GERM THEORY OF DISEASE

The discovery of the anesthetic power of drugs was destined presently, in addition to its direct

beneficences, to aid greatly in the progress of scientific medicine, by facilitating those experimental studies of animals from which, before the day of anesthesia, many humane physicians were withheld, and which in recent years have led to discoveries of such inestimable value to humanity. But for the moment this possibility was quite overshadowed by the direct benefits of anesthesia, and the long strides that were taken in scientific medicine during the first fifteen years after Morton's discovery were mainly independent of such aid. These steps were taken, indeed, in a field that at first glance might seem to have a very slight connection with medicine. Moreover, the chief worker in the field was not himself a physician. He was a chemist, and the work in which he was now engaged was the study of alcoholic fermentation in vinous liquors. Yet these studies paved the way for the most important advances that medicine has made in any century towards the plane of true science; and to this man more than to any other single individual—it might almost be said more than to all other individuals—was due this wonderful advance.

It is almost superfluous to add that the name of this marvelous chemist was Louis Pasteur.

The studies of fermentation which Pasteur entered upon in 1854 were aimed at the solution of a controversy that had been waging in the scientific world with varying degrees of activity for a quarter of a century.

Back in the thirties, in the day of the early enthusiasm over the perfected microscope, there had arisen a new interest in the minute forms of life which Leeuwenhoek and some of the other

early workers with the lens had first described, and which now were shown to be of almost universal prevalence. These minute organisms had been studied more or less by a host of observers, but in particular by the Frenchman Cagniard Latour and the German of cell-theory fame, Theodor Schwann.

These men, working independently, had reached the conclusion, about 1837, that the micro-organisms play a vastly more important rôle in the economy of nature than any one previously had supposed. They held, for example, that the minute specks which largely make up the substance of yeast are living vegetable organisms, and that the growth of these organisms is the cause of the important and familiar process of fermentation. They even came to hold, at least tentatively, the opinion that the somewhat similar micro-organisms to be found in all putrefying matter, animal or vegetable, had a causal relation to the process of putrefaction.

This view, particularly as to the nature of putrefaction, was expressed even more outspokenly a little later by the French botanist Turpin.

Views so supported naturally gained a following; it was equally natural that so radical an innovation should be combated.

In this case it chanced that one of the most dominating scientific minds of the time, that of Liebig, took a firm and aggressive stand against the new doctrine. In 1839 he promulgated his famous doctrine of fermentation, in which he stood out firmly against any "vitalistic" explanation of the phenomena, alleging that the presence of micro-organisms in fermenting and putrefy-

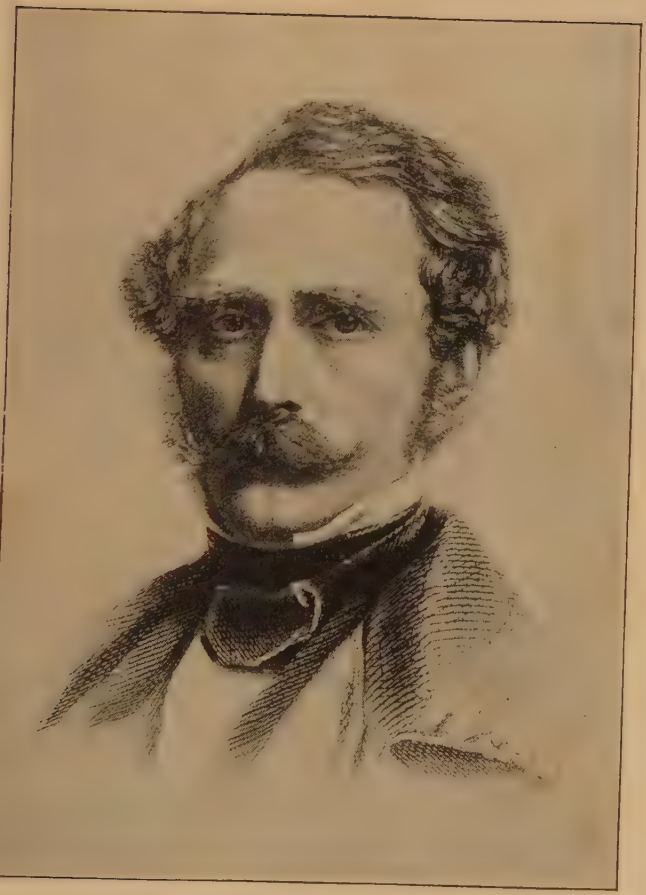
ing substances was merely incidental, and in no sense causal.

This opinion of the great German chemist was in a measure substantiated by experiments of his compatriot Helmholtz, whose earlier experiments confirmed, but later ones contradicted, the observations of Schwann, and this combined authority gave the vitalistic conception a blow from which it had not rallied at the time when Pasteur entered the field. Indeed, it was currently regarded as settled that the early students of the subject had vastly over-estimated the importance of micro-organisms.

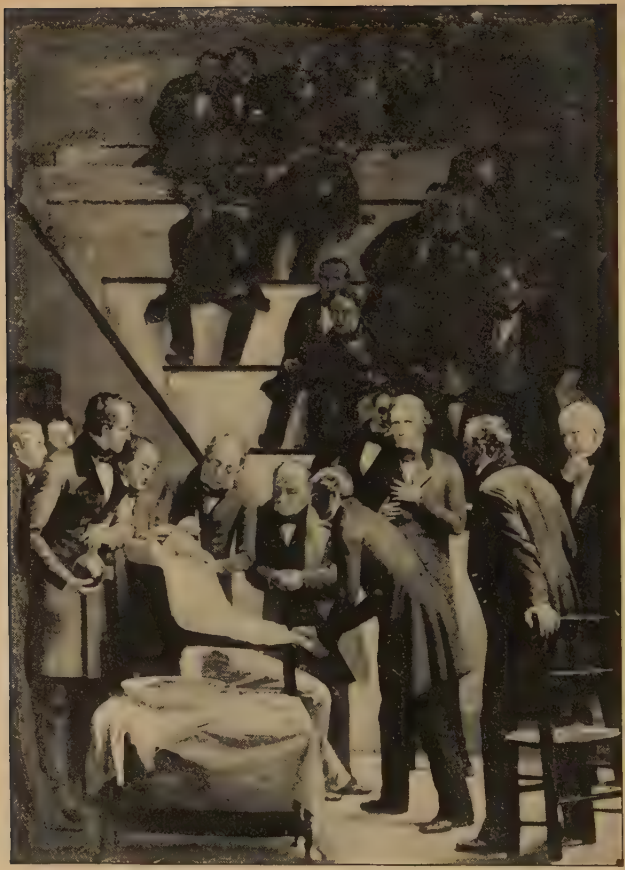
And so it came as a new revelation to the generality of scientists of the time, when, in 1857 and the succeeding half-decade, Pasteur published the results of his researches, in which the question had been put to a series of altogether new tests, and brought to unequivocal demonstration.

He proved that the micro-organisms do all that his most imaginative predecessors had suspected, and more. Without them, he proved, there would be no fermentation, no putrefaction—no decay of any tissues, except by the slow process of oxidation. It is the microscopic yeast-plant which, by seizing on certain atoms of the molecule, liberates the remaining atoms in the form of carbonic-acid and alcohol, thus effecting fermentation; it is another microscopic plant—a bacterium, as Devaine had christened it—which in a similar way effects the destruction of organic molecules, producing the condition which we call putrefaction.

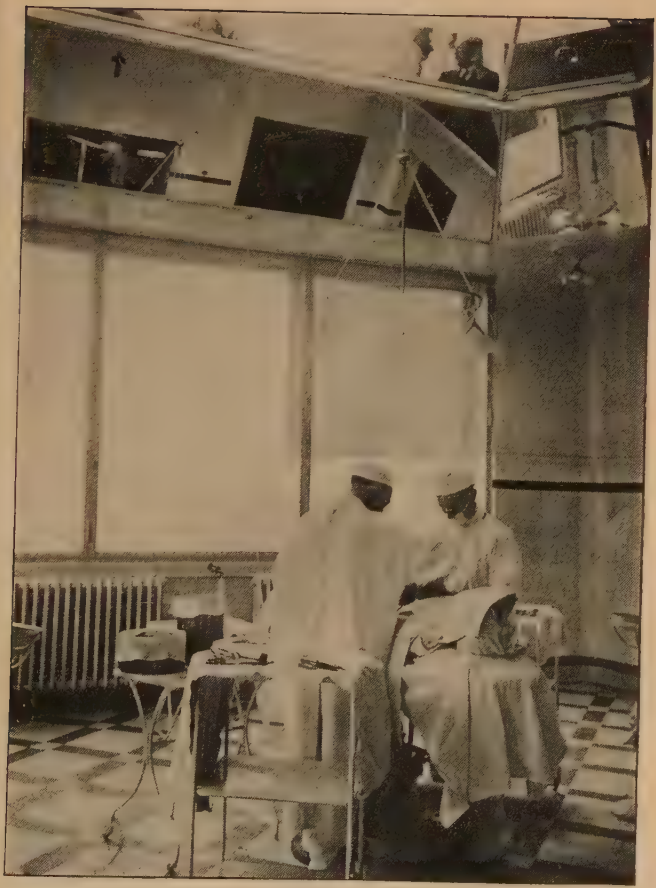
Pasteur showed, to the amazement of biologists, that there are certain forms of these bacteria which secure the oxygen which all organic life



DR. WILLIAM T. G. MORTON, THE FATHER OF PAINLESS SURGERY



MORTON'S FIRST PUBLIC DEMONSTRATION OF THE ANAESTHETIC POWER OF ETHER AT THE MASSACHUSETTS GENERAL HOSPITAL IN BOSTON



STUDENTS AND VISITING PHYSICIANS AT ST. MICHAEL'S HOSPITAL IN PARIS WITNESS OPERATIONS THROUGH THE GLASS CEILING AND HEAR COMMENT OF THE OPERATING SURGEON TRANSMITTED BY RADIO MICROPHONE

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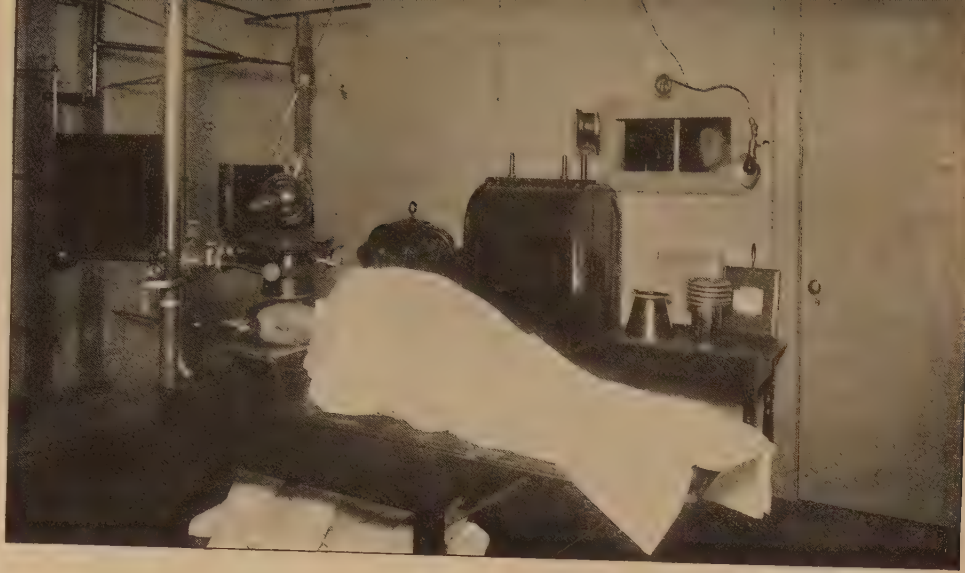
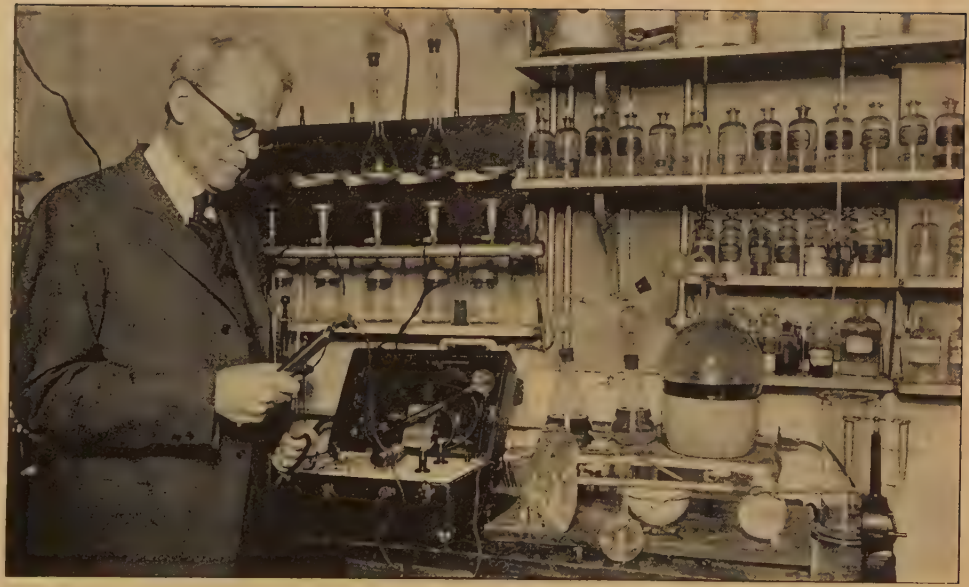
ASEPTIC SURGERY IN A TYPICAL MODERN OPERATING ROOM



MODERN X-RAY APPARATUS OPERATED FROM ADJOINING ROOM

DESICCATING ANIMAL TISSUES FOR EXPERIMENTAL USE AT THE LOOMIS LABORATORY IN NEW YORK

PULVERIZING DRIED ANIMAL TISSUES BY GRINDING
AT THE LOOMIS LABORATORY



LIGHTING AN ELECTRIC BULB WITH HIGH-FREQUENCY CURRENT SENT THROUGH THE BODY IN THE AUTHOR'S LABORATORY OF BIO-CHEMISTRY AND EXPERIMENTAL THERAPEUTICS IN NEW YORK

requires, not from the air, but by breaking up unstable molecules in which oxygen is combined; that putrefaction, in short, has its foundation in the activities of these so-called anaerobic bacteria.

In a word, Pasteur showed that all the many familiar processes of the decay of organic tissues are, in effect, forms of fermentation, and would not take place at all except for the presence of the living micro-organisms. A piece of meat, for example, suspended in an atmosphere free from germs, will dry up gradually, without the slightest sign of putrefaction, regardless of the temperature or other conditions to which it may have been subjected. He presented his results in his numerous papers before the Academy of Sciences.

There was nothing in these studies bearing directly upon the question of animal diseases, yet before they were finished they had stimulated progress in more than one field of pathology. At the very outset they sufficed to start afresh the inquiry as to the rôle played by micro-organisms in disease.

In particular they led the French physician Devaine to return to some interrupted studies which he had made ten years before in reference to the animal disease called anthrax, or splenic fever, a disease that cost the farmers of Europe millions of francs annually through loss of sheep and cattle.

In 1850 Devaine had seen multitudes of bacteria in the blood of animals that had died of anthrax, but he did not at that time think of them as having a causal relation to the disease. Now, however, in 1863, stimulated by Pasteur's new revelations regarding the power of bacteria, he returned to

the subject, and soon became convinced, through experiments by means of inoculation, that the microscopic organisms he had discovered were the veritable and the sole cause of the infectious disease anthrax.

The publication of this belief in 1863 aroused a furor of controversy. That a microscopic vegetable could cause a virulent systemic disease was an idea altogether too startling to be accepted in a day, and the generality of biologists and physicians demanded more convincing proofs than Devaine as yet was able to offer.

Naturally a host of other investigators all over the world entered the field. Foremost among these was the German Dr. Robert Koch, who soon corroborated all that Devaine had observed, and carried the experiments further in the direction of the cultivation of successive generations of the bacteria in artificial media, inoculations being made from such pure cultures of the eighth generation, with the astonishing result that animals thus inoculated succumbed to the disease.

Such experiments seem demonstrative, yet the world was unconvinced, and in 1876, while the controversy was still at its height, Pasteur was prevailed upon to take the matter in hand.

The great chemist was becoming more and more exclusively a biologist as the years passed, and in recent years his famous studies of the silk-worm diseases, which he proved due to bacterial infection, and of the question of spontaneous generation, had given him unequalled resources in microscopical technique. And so when, with the aid of his laboratory associates Duclaux and Chamberland and Roux, he took up the mooted anthrax

question the scientific world awaited the issue with bated breath. And when, in 1877, Pasteur was ready to report on his studies of anthrax, he came forward with such a wealth of demonstrative experiments—experiments the rigid accuracy of which no one would for a moment think of questioning—going to prove the bacterial origin of anthrax, that skepticism was at last quieted for all time to come.

Henceforth no one could doubt that the contagious disease anthrax is due exclusively to the introduction into an animal's system of a specific germ—a microscopic plant—which develops there. And no logical mind could have a reasonable doubt that what is proved true of one infectious disease would some day be proved true also of other, perhaps of all, forms of infectious maladies.

Hitherto the cause of contagion, by which certain maladies spread from individual to individual, had been a total mystery, quite unillumined by the vague terms "miasm," "humor," "virus," and the like cloaks of ignorance. Here and there a prophet of science, as Schwann and Henle, had guessed the secret; but guessing, in science, is far enough from knowing. Now, for the first time, the world *knew*, and medicine had taken another gigantic stride towards the heights of exact science.

LISTER AND ANTISEPTIC SURGERY

Meantime, in a different tho allied field of medicine there had been a complementary growth that led to immediate results of even more practical importance. I mean the theory and practise of antisepsis in surgery. This advance, like the

other, came as a direct outgrowth of Pasteur's fermentation studies of alcoholic beverages, tho not at the hands of Pasteur himself. Struck by the boundless implications of Pasteur's revelations regarding the bacteria, Dr. Joseph Lister (later Lord Lister), of Glasgow, set about as early as 1860 to make a wonderful application of these ideas. If putrefaction is always due to bacterial development, he argued, this must apply as well to living as to dead tissues; hence the putrefactive changes which occur in wounds and after operations on the human subject, from which blood-poisoning so often follows, might be absolutely prevented if the injured surfaces could be kept free from access of the germs of decay.

In the hope of accomplishing this result, Lister began experimenting with drugs that might kill the bacteria without injury to the patient, and with means to prevent further access of germs once a wound was freed from them.

How well he succeeded all the world knows; how bitterly he was antagonized for about a score of years, the world has forgotten. As early as 1867 Lister was able to publish results pointing towards success in his great project; yet so incredulous were surgeons in general that even some years later the leading surgeons on the Continent had not so much as heard of his effort. In 1870 the soldiers of Paris died, as of old, of hospital gangrene; and when, in 1871, the French surgeon Alphonse Guérin, stimulated by Pasteur's studies, conceived the idea of dressing wounds with cotton in the hope of keeping germs from entering them, he was quite unaware that a British contemporary had preceded him by a full decade

in this effort at prevention and had made long strides toward complete success.

Lister's priority, however, and the superiority of his method, were freely admitted by the French Academy of Sciences, which in 1881 officially crowned his achievement, as the Royal Society of London had done the year before.

By this time, to be sure, as everybody knows, Lister's new methods had made their way everywhere, revolutionizing the practise of surgery and practically banishing from the earth maladies that hitherto had been the terror of the surgeon and the opprobrium of his art. And these bedside studies, conducted in the end by thousands of men who had no knowledge of microscopy, had a large share in establishing the general belief in the causal relation that micro-organisms bear to disease, which by about the year 1880 had taken possession of the medical world.

But they did more; they brought into equal prominence the idea that, the cause of a diseased condition being known, it may be possible as never before to grapple with and eradicate that condition.

PREVENTIVE INOCULATION

The controversy over spontaneous generation, which, thanks to Pasteur and Tyndall, had just been brought to a termination, made it clear that no bacterium need be feared where an antecedent bacterium had not found lodgment; Listerism in surgery had now shown how much might be accomplished towards preventing the access of germs to abraded surfaces of the body and de-

stroying those that already had found lodgment there.

As yet, however, there was no inkling of a way in which a corresponding onslaught might be made upon those other germs which find their way into the animal organism by way of the mouth and the nostrils, and which, as was now clear, are the cause of those contagious diseases which, first and last, claim so large a proportion of mankind for their victims. How such means might be found now became the anxious thought of every imaginative physician, of every working microbiologist.

As it happened, the world was not kept long in suspense. Almost before the proposition had taken shape in the minds of the other leaders, Pasteur had found a solution.

Guided by the empirical success of Jenner, he, like many others, had long practised inocluation experiments, and on February 9, 1880, he announced to the French Academy of Sciences that he had found a method of so reducing the virulence to a disease germ that when introduced into the system of a susceptible animal it produced only a mild form of the disease, which, however, sufficed to protect against the usual virulent form exactly as vaccina protects against small-pox.

The particular disease experimented with was that infectious malady of poultry known familiarly as "chicken cholera." In October of the same year Pasteur announced the method by which this "attenuation of the virus," as he termed it, had been brought about—by cultivation of the disease germs in artificial media, exposed to the air, and he did not hesitate to assert his belief that the

method would prove "susceptible of generalization"—that is to say, of application to other diseases than the particular one in question.

Within a few months he made good this prophecy, for in February, 1881, he announced to the Academy that with the aid, as before, of his associates MM. Chamberland and Roux, he had produced an attenuated virus of the anthrax microbe by the use of which, as he affirmed with great confidence, he could protect sheep, and presumably cattle, against that fatal malady.

This announcement was immediately challenged in a way that brought it to the attention of the entire world. The president of an agricultural society, realizing the enormous importance of the subject, proposed to Pasteur that his alleged discovery should be submitted to a decisive public test. He proposed to furnish a drove of fifty sheep half of which were to be inoculated with the attenuated virus of Pasteur. Subsequently all the sheep were to be inoculated with virulent virus, all being kept together in one pen under precisely the same conditions. The "protected" sheep were to remain healthy; the unprotected ones to die of anthrax; so read the terms of the proposition.

Pasteur accepted the challenge; he even permitted a change in the program by which two goats were substituted for two of the sheep, and ten cattle added, stipulating, however, that since his experiments had not yet been extended to cattle these should not be regarded as falling rigidly within the terms of the test.

It was a test to try the soul of any man, for all the world looked on askance, prepared to deride

the maker of so preposterous a claim as soon as his claim should be proved baseless. Not even the fame of Pasteur could make the public at large, lay or scientific, believe in the possibility of what he proposed to accomplish. There was time for all the world to be informed of the procedure, for the first "preventive" inoculation—or vaccination, as Pasteur termed it—was made on May 5th, the second on May 17th, and another interval of two weeks must elapse before the final inoculations with the unattenuated virus. Twenty-four sheep, one goat, and five cattle were submitted to the preliminary vaccinations.

Then, on May 31st, all sixty of the animals were inoculated, a protected and unprotected one alternately, with an extremely virulent culture of anthrax microbes that had been in Pasteur's laboratory since 1877. This accomplished, the animals were left together in one enclosure to wait the issue.

Two days later, June 2d, at the appointed hour of rendezvous, a vast crowd, composed of veterinary surgeons, newspaper correspondents, and farmers from far and near, gathered to witness the closing scenes of this scientific tourney.

What they saw was one of the most dramatic scenes in the history of peaceful science—a scene which, as Pasteur declared afterwards, "amazed the assembly." Scattered about the enclosure, dead, dying, or manifestly sick unto death, lay the unprotected animals, one and all, while each and every "protected" animal stalked unconcernedly about with every appearance of perfect health. Twenty of the sheep and the one goat were already dead; two other sheep expired under the eyes of

the spectators; the remaining victims lingered but a few hours longer.

Thus in a manner theatrical enough, not to say tragic, was proclaimed the unequivocal victory of science.

Naturally enough, the unbelievers struck their colors and surrendered without terms; the principle of protective vaccination, with a virus experimentally prepared in the laboratory, was established beyond the reach of controversy.

That memorable scientific battle marked the beginning of a new era in medicine. It was a foregone conclusion that the principle thus established would be still further generalized; that it would be applied to human maladies; that in all probability it would grapple successfully, sooner or later, with many infectious diseases.

That expectation advanced rapidly towards realization. Pasteur himself made the application to the human subject in the disease hydrophobia in 1885, since which time that hitherto most fatal of maladies has largely lost its terrors. Thousands of persons bitten by mad dogs have been snatched from the fatal consequences of that mishap by this method at the Pasteur Institute in Paris, and at the similar institutes, built on the model of this parent one, that have been established all over the world.

SERUM-THERAPY

In the production of the rabies vaccine Pasteur and his associates developed a method of attenuation of a virus quite different from that which had been employed in the case of the vaccines of chicken cholera and of anthrax.

The rabies virus was inoculated into the system of guinea-pigs or rabbits and, in effect, cultivated in the systems of these animals. The spinal cord of these infected animals was found to be rich in the virus, which rapidly became attenuated when the cord was dried in the air. The preventive virus, of varying strengths, was made by maceration of these cords at varying stages of desiccation.

This cultivation of a virus within the animal organism suggested, no doubt, by the familiar Jennerian method of securing small-pox vaccine, was at the same time a step in the direction of a new therapeutic procedure which was destined presently to become of all-absorbing importance—the method, namely, of so-called serum-therapy, or the treatment of a disease with the blood serum of an animal that has been subjected to protective inoculation against that disease.

The possibility of such a method was suggested by the familiar observation, made by Pasteur and numerous other workers, that animals of different species differ widely in their susceptibility to various maladies, and that the virus of a given disease may become more and more virulent when passed through the systems of successive individuals of one species, and, contrariwise, less and less virulent when passed through the systems of succesive individuals of another species.

These facts suggested the theory that the blood of resistant animals might contain something directly antagonistic to the virus, and the hope that this something might be transferred with curative effect to the blood of an infected susceptible animal. Numerous experimenters all over the world

made investigations along the line of this alluring possibility, the leaders being Drs. Von Behring and Kitasato, closely followed by Dr. Roux and his associates of the Pasteur Institute of Paris. Definite results were announced by Behring in 1892 regarding two important diseases—tetanus and diphtheria—but the method did not come into general notice until 1894, when Dr. Roux read an epoch-making paper on the subject at the Congress of Hygiene at Buda-Pesth.

In this paper Dr. Roux, after adverting to the labors of Behring, Ehrlich, Boer, Kossel, and Wassermann, described in detail the methods that had been developed at the Pasteur Institute for the development of the curative serum, to which Behring had given the since-familiar name antitoxin. The method consists, first, of the cultivation, for some months, of the diphtheria bacillus (called the Klebs-Loeffler bacillus, in honor of its discoverers) in an artificial bouillon, for the development of a powerful toxin capable of giving the disease in a virulent form.

This toxin, after certain details of mechanical treatment, is injected in small but increasing doses into the system of an animal, care being taken to graduate the amount so that the animal does not succumb to the disease. After a certain course of this treatment it is found that a portion of blood serum of the animal so treated will act in a curative way if injected into the blood of another animal, or a human patient, suffering with diphtheria. In other words, according to theory, an antitoxin has been developed in the system of the animal subjected to the progressive inoculations of the diphtheria toxin.

In Dr. Roux's experience the animal best suited for the purpose is the horse, tho almost any of the domesticated animals will serve the purpose.

But Dr. Roux's paper did not stop with the description of laboratory methods. It told also of the practical application of the serum to the treatment of numerous cases of diphtheria in the hospitals of Paris—applications that had met with a gratifying measure of success. He made it clear that a method had been found of coping successfully with what had been one of the most virulent and intractable of the diseases of childhood. Hence it was not strange that his paper made a sensation in all circles, medical and lay alike.

Physicians from all over the world flocked to Paris to learn the details of the open secret, and within a few months the new serum-therapy had an acknowledged standing with the medical profession everywhere. What it has accomplished was regarded as but an earnest of what the new method might accomplish presently when applied to the other infectious diseases.

Efforts at such applications were immediately begun in numberless directions—had, indeed, been under way in many a laboratory for some years before. Soon it was clear that this method also is susceptible of the widest generalization. There was early announcement, in some cases rather premature, of specific antitoxins of tetanus, cholera, typhus-fever, pneumonia, and tuberculosis—a set of diseases which in the aggregate account for a startling proportion of the general death-rate. Then Dr. Yersin, with the collaboration of his former colleagues of the Pasteur In-

stitute, developed, and used with success, an antitoxin from the microbe of the plague which had recently ravaged China.

Dr. Calmette, another graduate of the Pasteur Institute, extended the range of the serum-therapy to include the prevention and treatment of poisoning by venoms, and developed an antitoxin that was to give immunity from the lethal effects of snake bites to thousands of persons in India and Australia.

Looking back after the lapse of a quarter century, we may freely admit that serum-therapy stands as the culminating achievement in medicine of the nineteenth century. Its later development, and the divergent methods that grew out of it, will claim our attention in a later chapter. Meantime we may acclaim the rigidly experimental method which did so much to bring medicine for a level of fanciful empiricism to the plane of a rational experimental science.

CHAPTER II

BANISHING THE PLAGUES

"A VERY small, frail man; obviously nervous in temperament and doubtless on occasion irritable, but in our interview most gracious."

I find this entry in my note book in reference to a visit to the late Paul Ehrlich at his famous laboratory in Frankfort on the Main. As I recall the occasion, the picture of the man that comes to my mind emphasizes the appearance of alertness, quickness of apprehension, nervous energy of action that characterize the great scientific investigator;—traits that doubtless accounted in no small measure for his achievements.

But there also comes to mind the recollection of a seemingly naive personality no less characteristic of a man whose life has been chiefly spent viewing the world through a microscope and looking beyond the limits of the visible to picture in imagination the activities of unseen molecules and atoms.

I recall the obvious and open pride, the boyish enthusiasm, with which the great savant beckoned me to one side of his room to inspect some wax models.

"Aren't they wonderful!" he exclaimed. His eye twinkled, and he whispered as if in confidence: "You know if I were to put them in the fire they would melt." Then after a pause: "That is why I do not put them in the fire." A hearty laugh followed, indicating that the propounder of the

subtlest theory of vital action in connection with disease and immunity that has ever been suggested, regarded this as a very clever witticism.

Nor could the visitor fail to enter into the spirit of the recital. There was a delightfully child-like simplicity in the way of speaking, as also in the manner of the famous investigator as he posed for his photograph, that quite won the heart. Did you expect a disquisition on some obscure phase of science? Instead of this the savant makes a witticism and offers you a cigar, assuring you that smoking is the greatest pleasure of life. Moreover, the entire manner and speech of this distingished authority in the field of experimental medicine seemed to betoken the modesty, self-forgetfulness, simplicity of view that always—or almost always—characterize the truly great personality.

The work which brought the name of Ehrlich to the attention of the general public throughout the world in the year 1910 was the discovery of a specific given to the medical profession under the name of "606," and subsequently christened salvarsan; a more soluble form of the drug soon after being synthesized and christened neo-salvarsan. This drug, when injected hypodermically into the tissues or into a vein has the extraordinary property of searching out the so-called *Spirochæta pallidum*, and killing this germ without injuring the unwilling host in whose blood and tissues it has found lodgment. The drug is therefore a specific in the most restricted use of that word. It is aimed to destroy a particular germ, and it goes a long way toward accomplishing this purpose.

The discovery of this remarkable specific did not come about by accident. The drug was nicknamed "606" because 605 syntheses of allied drugs had been made unsuccessfully, from the same derivative (atoxyl), compounded of arsenic and a coal-tar product. This puts the discovery of salvarsan on an altogether different footing from the empirical discovery made several decades earlier, that drugs extracted from the cinchona plant have specific power against the germs of malaria.

In point of fact, the discovery of Ehrlich may be said to have come as the logical sequence of a line of thought and investigation to which almost his entire working life had been devoted.

The discoverer first became known to pathologists many years earlier through his investigation of stains for microscopic tissues. He devised some remarkable compounds through which he was enabled to stain differentially the different types of white blood corpuscles, proving that these curious cells are not all of one family. Elie Metchnikoff had shown that a function of the white blood corpuscles is to act as a scavenger in the blood, attacking and devouring the noxious germs that find entrance to the body. Ehrlich showed that it is particular tribes of the leucocytes, more especially the ones which came to be known as polymorphs (polynuclear leucocytes) that make up the company of germ-fighters, which Metchnikoff had christened phagocytes or cell-eaters. Another type of leucocyte Ehrlich christened the eosinophil (lover of eosin) because of the readiness with which it absorbs the eosin stain.

The functions of the less numerous tribes of

leucocytes had not then been very clearly made out; but their discovery was a step in the revelation of the complexity of the blood which has been supplemented, on the physiological side, by the studies in immunization, and by such remarkable demonstrations as Professor G. H. F. Nuttall's tests through which the genetic relationship of different animals may be shown by examining a few drops of blood serum. The newer theory as to the action of the leucocytes (in cooperation with the red corpuscles) in dealing with extraneous non-bacterial proteins in the blood stream is elsewhere referred to.

THE SIDE-CHAIN THEORY

Notwithstanding his successes in the anatomical investigations, Ehrlich's interests all along centered on the physiological and chemical aspects of the problems of medical science. He made very notable contributions to the theory of the new science of immunity not long after the investigations of Von Behring gave the diphtheria antitoxin to the world. Ehrlich experimented with certain vegetable products, notably ricin, a derivative of the castor oil bean. His line of research had to do with rendering animals immune to these poisons by giving them repeated small doses of the drug. A conspicuous immediate result of these experiments was the development (about 1897) of Ehrlich's theory of immunity, which came to be regarded as the most plausible hypothesis hitherto advanced in explanation of the observed facts of immunity to bacterial diseases. Ehrlich called his explanation the side-chain theory.

This very interesting hypothesis, altho based on a vast range of observations, is of necessity altogether theoretical. But it proved of great importance in enabling workers in many fields to visualize what at least are the possible conditions in the human system through which it comes to pass that the person who has recovered from a bacterial disease is very generally immune for a time to further attacks from that disease; and also the allied fact that an antitoxin, developed in the system of an animal, may be transferred with curative effect to the system of a patient suffering from the bacterial toxin,—as illustrated in the familiar case of the Von Behring cure for diphtheria.

The side-chain theory in its fully developed form, as expounded, for example, by Ehrlich before the Royal Society of London in his Croonian lecture, in 1900, is a very elaborate hypothesis. It assumes that the toxin produced by a pathogenic bacterium, the poisonous effects of which produce the symptoms of disease, consists essentially of ultra-microscopic particles which may be conceived as having definite forms, varying with different types of bacteria, but uniform in the case of any given toxin.

A graphic idea of what takes place when the particles of a toxin circulate in the blood of a patient may be gained if we think of each poison-conveying particle as having a specific form that enables it to fit into a corresponding particle of the normal cellular tissues somewhat as a key fits into a lock. If the toxic particles are introduced into the system in sufficient quantities, they link themselves in large numbers with the body

cells, thereby conveying their poison to the essential living tissues, and disturbing the physiological processes so profoundly as perhaps to cause the death of the patient.

But the bodily cells, if not too quickly overpowered, tend to combat the enemy by sending out what may be called antibodies which are of such form as to unite with the toxic particles. Each toxic particle thus united with an antibody is like a key permanently fitted into a detachable lock. Toxin and antitoxin (key and lock) then float in the blood stream harmlessly, and in course of time are excreted from the body.

As nature does nothing by halves, the cells that send out the antitoxin are not content to produce just particles enough to checkmate each toxic particle. They send out a surplus supply, and these supernumerary particles float unattached in the blood for an indefinite period, ready at any time to attach themselves to toxins of the particular kind that evoke their presence. And persons in whose blood stream such antitoxic particles or antibodies are present are immune to the specific disease whose toxins provoked the sending out of these antibodies.

The graphic diagrams with which Ehrlich illustrates his theory are of course purely imaginary, inasmuch as toxins and antitoxins alike lie far beyond the range of the microscope. But it is always helpful to the investigator of abstruse topics to be able to visualize his work. As I said before, the side-chain theory holds a unique place in this regard. It is applicable all along the line in the studies of immunization, and it was pretty generally accepted as a working hypothesis. The

specific blood tests of Widal for typhoid fever and of Von Wassermann for syphilis were developed and explained in the light of the side-chain theory; and the new vaccine therapy, which stimulates the cells to act by introducing dead toxic germs, falls equally within its scope.

The theory may also be used to explain the very puzzling phenomena of excessive susceptibility to certain protein substances—blood-serum, white of egg, and vegetable albumens, as well as bacterial proteins—to which the term *anaphylaxis* is applied. Among the important benefits derived from the theory have been those associated with the work of Ehrlich himself, and his immediate associates, in the development of the new chemotherapy. The developers of vaccine therapy and of nonspecific protein therapy have at least used the Ehrlichian theory of immunization as a point of departure in the basic study of blood conditions.

THE SEARCH FOR SPECIFICS

The very essence of the side-chain theory, it will be observed, is the assumption that each specific toxin has unit particles of a definite shape and can be combated only by particles of complementary shape,—just as a given key fits only its companion lock. A vast body of observations in varied fields has tended to support this idea of the specific character of the toxins that are able to produce deleterious effects on living tissues. The idea runs counter to the crude general notion that whatever is poisonous to one protoplasmic cell is poisonous to another. But the evidence strongly supports the new theory. Indeed the fact that an antitoxic serum—such as Behring's diphtheria

antitoxin—counteracts the diphtheria toxin and no other, brings the theory of the specific nature of toxins and antitoxins to substantial demonstration.

Such being the case, and it being tolerably clear that the body is able, under favorable conditions, to produce a specific antidote for each type of bacterial toxin, it seemed to Ehrlich within the possibilities that synthetic chemistry might be able to develop corresponding antidotes in the laboratory test tube. His own early work had shown, as we have seen, that certain dyes of the anilin series have the property of staining cells of one type and leaving cells of an allied type unstained; so it occurred to him that by utilizing this selective affinity of the anilin dye, and combining this agent with a drug that is toxic to protoplasm, he might be able to develop specifics which would search out a particular type of disease germ and destroy it without injuring the tissues of the patient in whose system the disease germ lurked and proliferated.

The attempt to put this idea in practise involved almost numberless complications. To mention a single one, it was early discovered that tests of the germicide power of any given drug when made in the test tube are not to be relied upon. The test must be made in the tissues of the living organism. Obviously a human being can not be used for this; but fortunately the tests made with the lower animals, notably guinea-pigs, rabbits, and mice, afford clues that have a large measure of reliability. It is with the aid of these agents that the remarkable work of recent decades in combating germ diseases has been carried out.

The attempts of Ehrlich to develop antidotes

in the test tube were first directed against the protozoal germs of the deadly African disease called sleeping sickness. Ehrlich finally developed a compound of atoxyl having undoubted efficacy in destroying the protozoon, called a trypanosome, that causes the disease. Unfortunately the remedy was found to produce bad after-effects, sometimes causing permanent blindness. But the use of the drug salvarsan, which was the next important development, seems to have no bad sequel.

THE ULTRA-MICROSCOPE

In the attempt to discover the causal agent for small-pox and the allied maladies whose germs have hitherto eluded detection, it has been found that a virus capable of transmitting the disease may retain its noxious features after being passed through an unglazed porcelain filter. Similarly Dr. Peyton Rous of the Rockefeller Institute, who has had great experience in cultivating cancer and in transferring the abnormal virus from one animal to another, including mice, rats, and chickens, appears to have produced cancer in an animal by injecting a liquid that had been passed through such a filter. This means that no bacteria of a size visible under the most powerful microscope remained.

It is thought by some observers, that ultra-microscopic particles, conceivably living germs of an order almost infinitely smaller than bacteria, have been detected. The particles in question, whether or not they hold this relation to disease, are observed with the use of the so-called ultra-microscope, which owes its origin to Zsigmondy working in 1901 and to Siedentopf in 1903. The

method developed by these workers consists of letting a concentrated beam of light cut across the microscopic field without entering the lens of the microscope.

The rays of light beating against exceedingly minute particles of matter are diffracted or dissipated in every direction, and to the observer who peers into the otherwise totally dark field of the microscope they will appear as sparks of light. It has been found possible by this method to reveal the presence of particles that are estimated to be not more than ten times the size of a molecule. Such particles lie far beyond the limits of direct vision even under the most powerful magnification.

The effect will be understood if we recall the familiar observation that a beam of light penetrating a dark room through a hole in the shutter, reveals the presence of myriads of motes, floating in the atmosphere, which disappear instantly when they float outside the light-shaft. This method was used by Professor Tyndall to test the presence of bacteria in the air, and he found that the naked eye, with the aid of the sunbeam, could detect the presence of spores that otherwise would be invisible except with the aid of a microscope magnifying perhaps a thousand diameters.

The beam of light passing through the field of the ultra-microscope, since it is viewed through a magnifying lens, reveals particles infinitely more minute. These exceedingly fine particles are thus observed to be incessantly dancing about in a zig-zag motion which would be quite inexplicable except on the supposition that they are being buffeted by the invisible molecules of the solution

in which they are found. The degree of activity of ultra-microscopic particles varies, as might be expected, with the strength of the solution; which is in harmony with Van't Hoff's theory of osmosis detailed elsewhere in this series.

It remains to be demonstrated whether the ultra-microscopic particles hitherto observed bear a definite and causal relation to any disease.

It is always possible that a germ of microscopic size may escape detection because no proper method has yet been devised of staining it and making it visible. It will be recalled that the now familiar bacillus of tuberculosis escaped detection until Dr. Robert Koch devised a special stain in the year 1882; and the *Spirochæta* or *Treponema pallidum,* which is a relatively long organism of corkscrew shape, was not discovered until 1905, when Schandinn and Hoffmann devised a stain that renders it visible.

The germ of rabies was unknown until the summer of 1913, when Dr. Hideyo Noguchi, the celebrated Japanese pathologist, announced from the Rockefeller Institute of New York the discovery of a protozoal organism in the virus.

LIGHT AS A GERMICIDE

It has long been known that the rays of sunlight furnish the all-essential stimuli that make possible the work of the vegetable cell in performing the miracles of transforming inorganic into living matter. It now appears that the same light also contains rays that are directly inimical to the life of lower vegetable organisms. The fact was first demonstrated in connection with the treatment of the superficial malignant growth known as lupus,

which is due to the presence of the tubercle bacillus, growing in a localized colony, and not tending to spread inordinately, but proving so tenacious of its hold upon the territory already invaded that it was formerly regarded as almost ineradicable even with the use of the knife.

About the year 1895, a Danish physician, Dr. N. R. Finsen, developed a treatment for lupus which consists in exposing the diseased tissue to a concentrated beam of light rich in ultra-violet rays; that is to say, in the ethereal vibrations lying just beyond the violet end of the spectrum, and thus composed of light waves that are shorter than the shortest visible ones.

Dr. Finsen demonstrated that these short waves of light destroy bacteria. He was able with their aid to kill the tubercle bacilli in the diseased tissues and thus to cure a very large proportion of cases of lupus. Ultra-violet light thus used came to be known as the "Finsen ray."

The germicidal effect of ultra-violet light has since been everywhere recognized. The treatment of tuberculosis by direct sunlight, as carried out in hospitals established at high altitudes in the Alps, owes its efficacy to the ultra-violet rays coming directly from the sun. These rays, however, are obstructed by the air, and they have largely disappeared from sunlight at the sea level. They are altogether obstructed by glass; so the sun treatment of tuberculosis must be carried out in the open air.

It may be added that the children who receive this treatment in the Alpine hospitals are gradually inured to the cold until they can, without

discomfort, take their sunbaths in the open air stark naked even in the coldest weather.

Practical use has been made of the bactericidal properties of ultra-violet light in the purification of water. But the application of the method to the purification of milk has hitherto proved impracticable because, owing to the opacity of milk, the rays do not penetrate its substance to any considerable distance, and therefore leave the main bulk of the germs untouched.

It would appear, however, that a method has now been found to overcome this difficulty. The new method consists of the use of plates of quartz placed very close together, so that the milk passes between them in a thin film, and is thus sufficiently transparent to be suffused with the light of a mercury vapor electric lamp, the rays of which after passing through quartz are very rich in the short waves that characterize the spectrum beyond the violet.

The apparatus in question is merely a modified form of Peter Cooper Hewitt's quartz lamp; but rather curiously the experiments in sterilizing milk with the apparatus are being made in France. The reason for this, Mr. Hewitt explains, is that his quartz lamps are being extensively used in France in sterilizing drinking water, and their efficacy in this connection led to the idea of a similar purification of milk.

The French standards of purification for water are gratifyingly different from those of some American cities. The water is filtered and refiltered until it is so nearly free from all impurities as to attain a degree of transparency that permits print to be read with a telescope through eight

meters, or about 26 feet of water. Even water of this degree of limpidity may contain large numbers of bacteria. But when the water has been caused to flow in a zigzag channel past a large quartz lamp, specially devised for the purpose, the germs thus acted on by the ultra-violet rays are found to be either dead or so devitalized that they have very slight power of reproduction and hence are innocuous.

Should experiments prove conclusively that all the bacteria in milk are similarly killed by the ultra-violet rays, the observation will be one of vast practical importance, as means will be afforded of sterilizing milk, which, it would seem, must be superior to any previous method. For the moment, however, the familiar method of pasteurization, which consists of heating milk to about 142 degrees Fahrenheit for a period of three-quarters of an hour, is the recognized method of rendering this beverage wholesome. The question whether the vitamin content of the milk is thereby affected appears not to have been experimentally tested.

The pasteurization of milk is carried out on a very large scale by our modern dairies. After being pasteurized the milk is cooled by being allowed to pour down in miniature cataracts over successive pipes, the upper ones of which contain cool water, and the lower ones brine almost at a freezing temperature. The milk is thus chilled in a few minutes and is immediately placed in sterilized bottles.

Some interesting observations were made a few years ago by the New York Health Department in cooperation with the Rockefeller Institute, the

subjects being 500 babies in New York tenements. According to the observations, as reported by Dr. Wm. H. Park, Director of the Research Laboratory of the Health Department, 2 per cent. of babies using certified raw milk died, as did 8 per cent. of babies using good raw milk, and 14 per cent. of babies using grocery store milk; in addition to which 66 per cent. of the babies using grocery store milk became ill and required medical attention.

Meantime not a single baby died of the group using pasteurized milk.

Dr. Park emphasizes the fact that mother's milk is the best milk for a baby, but his observations show that pasteurized milk is next best. According to Mr. Hewitt, it is believed by the French chemists who tested the new method of sterilizing milk with the ultra-violet rays that milk purified by this method will be even more wholesome than pasteurized milk.

To appreciate the importance of the subject, it is only necessary to reflect that bacterial diseases of infancy, the major part of which have their inception in the ingestion of infected milk, constitute the deadliest of all plagues to which the modern world is subject. One-fifth of all deaths occur in early infancy.

A NEW REMEDY FOR CATTLE PLAGUE

Reference has been made to Ehrlich's attempted cure of sleeping sickness. This very fatal disease, which is mainly confined to the tropics, was studied at first hand by a commission under Dr. Robert Koch, who discovered that the agent of its transmission from one subject to another is the

tsetse fly. The germ that causes this disease, as already noted, is not a bacterium but a protozoon; that is to say, a single-celled animal organism of the lowest type. It has come to be known in recent years that many other tropical diseases are due to similar protozoal organisms. The plasmodium of malaria is also of the same type.

The protozoal germs differ from bacteria in that they for the most part have a double cycle of life-transformations, the two stages of their development being passed in the organisms of different animals. In the case of the malaria plasmodium, for example, as was first demonstrated by the Englishman Dr. Ronald Ross, one stage of development is passed in the organism of a mosquito of the genus *Anopheles,* which transmits the germ to the human subject in whose blood stream it undergoes the remaining stages of its development.

The various tropical contagious diseases are almost without exception transmitted by parasitical insects,—yellow fever, for example, by a mosquito of a different genus from that which transmits malaria, the Asiatic plague by fleas, and various cattle plagues and at least one disease of the temperate zone, the Rocky Mountain fever, by ticks.

In recent years the study of tropical diseases has become a special department of medicine, but the laboratories in which the investigations are prosecuted are not necessarily located in the tropics. In point of fact perhaps the chief center of such studies is at Cambridge University, England. The biologist in charge of this department of investigation is Dr. George H. F. Nuttall. His

official position is that of Quick Professor of Biology.

Professor Nuttall's studies of the blood have given him international reputation. In view of his professorship at Cambridge, and the further fact that he is a Fellow of the Royal Society, it is of peculiar interest to note that he is an American. His chief work, however, has been done in Germany and at Cambridge.

The coveted honor of election to Fellowship in the Royal Society was given Professor Nuttall in recognition of a very remarkable series of blood tests of which account has been given elsewhere. A still more recent investigation of Professor Nuttall has to do with a class of tropical animal diseases the germs of which are transmitted from one animal to another by ticks. The most important disease of this class from an American standpoint is the cattle plague known as Texas fever.

The discovery that ticks transmit this disease was made by an American, Dr. Theobald Smith, as long ago as 1889, and a method was devised whereby the animals were rid of the pests by being made to swim through a tank containing an antiseptic solution. But no remedy for the disease itself was discovered until Professor Nuttall began experimenting about the year 1907 with the drug known as trypan-blue.

The investigation was conducted at the experimental station at Cambridge, but the tests were repeated on a more extensive scale in South Africa; and it would appear that a valuable antidote for this malignant disease has been discovered. An objection to its use exists, however, in the case of animals that are to be slaughtered

for beef, in that the drug is a dye which stains the tissues more or less permanently.

TRANSFORMING THE PANAMA CANAL ZONE

Professor Nuttall has given much attention to another and even more important tropical disease of which man himself is the direct victim, namely, the plague. British interest is kept constantly stimulated by the prevalence of the plague in India, where almost 6,000,000 deaths occurred from this disease in the decade 1896-1907. The subject is of equal interest from an American standpoint because our own ports are from time to time threatened with an invasion of the plague. Tropical diseases in general are given a new aspect by the work that American physicians have accomplished in the region of the Panama Canal.

As to the latter, almost everyone knows in a general way that a once pestilential region has been made healthful, but comparatively few persons who have not visited the Canal Zone realize how radical was the metamorphosis effected by Colonel (later Surgeon General) W. C. Gorgas, U. S. A., the Chief Sanitary Officer, and his associates.

An outline of the work accomplished was given in an interesting article in the *Medical Record*, by Dr. J. Ewing Mears, of Philadelphia. He points out that the Isthmus had been known since the discovery of America as one of the most unhealthful regions of the globe; virtually uninhabitable to any but the few natives, who themselves fell victims in great numbers to the deadly scourges of malaria and yellow fever.

When an attempt was made in 1849 to construct

a railway across the Isthmus, so many laborers perished from disease that it became a proverbial saying that every railway tie represented the dead body of a workman.

The project of the Isthmian Canal prosecuted by the French from 1881 to 1892 may be described as a hopeless contest waged against disease. "In five years the French lost eleven-sixteenths of their working force, one-third of the number French subjects. Out of the twenty-four Sisters of Charity engaged in nursing in the Ancon Hospital, twenty died of yellow fever. Of seventeen engineers who came on one steamer, sixteen died." Little wonder that the French gave up the fight.

When Colonel Gorgas took charge of the sanitary policing of the Canal Zone in 1904, the conditions had not greatly changed. But within a single year he had so transformed them as virtually to have banished yellow fever, no single case of which has occurred in the Canal Zone since 1905. It has not been possible to deal with malaria in quite so radical a fashion; but this disease also has been held in check and in a large measure rendered innocuous.

As contrasted with the appalling mortality of the workmen under the French régime, it is sufficient to note that "in the year 1909 the annual death rate per thousand of 11,662 white employees was 6.43 from disease, and 3.43 from violence; total 9.86. Of Americans, of the 8,386, including employees and their families, the death rate per thousand was: From disease 4.05; from violence 2.27; total 6.32." So far as death from disease is concerned, this showing can be duplicated in very few communities of our most healthful re-

gions anywhere in the world. The average annual death rate in the United States in the same period was about 17 per thousand.

THE CONQUEST OF TROPICAL FEVERS

Interesting as these figures are in themselves, they become doubly significant when we reflect that the results were achieved through the rigid application of preventive measures based upon recently acquired knowledge as to the causation of disease. It is true that Dr. A. F. A. King, of Philadelphia, suggested as long ago as 1883 that malaria might be transmitted by the mosquito, but no one paid any attention to his suggestion, and it remained for Dr. Donald Ross to show that the mosquito is the real offender so recently as 1898.

Similarly the suggestion of Dr. Nott that yellow fever might be transmitted by the mosquito, made in 1848, remained quite unheeded; as did Dr. Charles J. Finlay's more detailed contention put forward in 1881. It was not until 1900 that the American authorities in Cuba were prevailed upon by Dr. Finlay to investigate his theory. Tests were made in which the lives of several army surgeons were jeopardized and that of one—Dr. Lazear—sacrificed. But in the end the accuracy of the view that Dr. Finlay had so long held was demonstrated.

Then it became clear that malaria and yellow fever are absolutely preventable diseases; that in order to eliminate them it would only be necessary to check the development of two tribes of mosquitoes—for it is a curious fact that only mosquitoes of the genus *Anopheles* can serve as host for the malarial germ, while only those of the

genus *Stegomyia* can act in similar capacity for the germ of yellow fever.

The elimination of mosquitoes might seem, indeed, to be no easy task; but that it is feasible in a region under strict military surveillance to guard against them most effectively, is clearly demonstrated in the results achieved by Dr. Gorgas.

BANISHING THE PEST-DISSEMINATING RAT

While yellow fever and malaria are thus guarded against through the waging of incessant war upon the mosquito, the danger of the introduction of plague is minimized by equally strenuous measures directed against the common house rat, since this animal serves as the host of the fleas that are the chief transmitters of the dreaded "black death."

It is now fully recognized that when the plague gains admission at a port it is brought by rats that have escaped from shipboard. Rats may transmit the disease to allied animals. In this way, for example, many of the ground squirrels once became infected in California; and in one case at least a child acquired the disease through being bitten by one of these animals.

Obviously, then, there is no ultimate safety except through destruction of the rats. But in the meantime much was accomplished in the Canal Zone by raising the houses three feet from the ground on supports of concrete or other material, covered with tin, so that the rats could not secure a footing on them. If placed on the ground they rested on a floor of concrete. The buildings were submitted to inspecton at regular intervals; those

not in a sanitary condition in the cities were placed in that condition, if possible, by the owner, or were condemned and destroyed.

Furthermore, direct war was waged upon the rat. Thus 17,000 of these animals were killed in Panama City in a single year. So rigid was the inspection of ships, and so effective the warfare upon the rats that the plague gained no foothold.

THE "TYPHOID FLY" AND ANTI-TYPHOID VACCINE

The chief remaining diseases that formerly ravaged the Canal Zone are typhoid fever and cholera. These diseases also depend to a considerable extent for transmission upon an insect host, the offender this time being the common housefly. War is waged upon the fly, as upon the mosquito, chiefly by destroying its breeding places.

So effective were these preventative measures that according to Dr. Mears "the fly has now become a *rara avis* within the Zone limits, and is very much less abundant than in the villages and towns of our country."

Dr. Mears declared that during his stay in the Canal Zone he saw but a *single specimen;* and we may readily accept his assertion that the comfort enjoyed owing to their absence is very great.

Unlike the flea and the mosquito, the fly does not transmit the disease germs directly to the human subject. Its action is indirect, in that it contaminates the foodstuffs. Food or milk brought from a distance may thus convey typhoid or cholera; but fortunately science is now provided, as we have seen, with the means of combating these diseases through inoculations that render the subject immune. We have seen that

the anti-typhoid vaccine was developed at the beginning of our century by Dr. (now Sir Almroth) Wright, then of the British Army service in India, but it made its way rather slowly, and its use in the United States Army was not made obligatory until August, 1911. The New York Board of Health began to manufacture it and dispense it for free administration in 1913.

The significance of this new agent of preventive medicine can be realized only by those who have a clear conception as to how great a scourge typhoid fever has always been in the past. In war time it has regularly claimed more victims than the enemy's bullets. Our troops in Cuba, as everyone will recall, were decimated by this scourge, which "stalked through the camp, apparently unrestrained, laying low one-sixth of the entire command." In the war of 1914-1918, as we have seen, all this was changed. Typhoid fever, thanks to the new knowledge of sanitation, combined with the use of the preventive vaccine, appears now to be as thoroughly subject to scientific control as small-pox has been since the original vaccine demonstration of Jenner.

NONSPECIFIC PROTEIN THERAPY

The value of antityphoid vaccine and other specific vaccines as therapeutic (in contradistinction to immunizing) agents has been the subject of much investigation. Latterly it has come to be recognized that benefits derivable from use of a particular vaccine may not be confined to a specific malady. For example, atityphoid vaccine has been rather extensively used in the treatment of various types of arthritis. The accredited ex-

planation is that we here have to do with a general or nonspecific protein response, based on the fact of the protein content of the vaccine, and quite independent of its bacterial toxins.

Very recently the terms "Protein Therapy" and "Nonspecific Protein Therapy" have come into vogue, and discussion of this new aspect of therapeutics now occupies a very prominent place in technical medical literature, particularly in Europe. In illustration of this, we may note that the *Quarterly Cumulative Index of Current Medical Literature* for 1922, issued by the American Medical Association, lists under "Protein" and "Protein Therapy" no fewer than 113 titles. For comparison, it may be added that only 33 titles are listed under "Vaccine" and "Vaccine Therapy," tho it should be further stated that these subjects are referred to in connection with other articles listed under the names of specific diseases.

In view of the very large proportion of foreign titles of these technical articles on protein therapy, it may be of interest to American physicians to recall that the present writer's initial statement of the generalized principle of the protein response in therapeutics was made in the *New York Medical Journal* in 1915; that there is, so far as he is aware, no earlier literature on the subject of any kind than that which records his original observations; and that the source documents of more permanent form are his monograph of December, 1916, entitled *The Proteal Treatment of Cancer and Allied Conditions,* and his book, published early in 1918 under title of *The Proteomorphic Theory and the New Medicine: An*

Introduction to Proteal Therapy (second edition, 1923).

These and the writer's additional articles in the *Medical Record* are technical presentations, based on personal investigations in laboratory and office, founded on studies of physiological chemistry and blood histology, and of no direct interest except to the medical profession. The applications of proteotherapy concern the interests of all persons who suffer from any malady associated with disturbance of protein metabolism; but this is not the place for general discussion of so technical a subject. It may not be amiss to explain, however, that the word "proteal" is merely a suggested generic term applicable to any vegetable protein in solution for therapeutic administration. The analogous word "proteil" is suggested for corresponding solutions of animal proteins—milk-protein, for example, or white of egg, both of which have been used quite extensively.

AN INSPIRING OBJECT LESSON

The report of the Department of Sanitation of the Isthmian Canal Commission for 1912 shows that the extraordinary work of making a once pestilential region salubrious was carried one stage farther by Dr. Gorgas and his associates, the death rate among employees being lower than ever before. It appears that in 1906 the death rate among employees was 41.73 per thousand, and in 1907, 28.74 per thousand, whereas in 1911 it was 11.02, and in 1912 only 9.18 per thousand. The death rate among white employees was only 3.25 per thousand, and the death rate from disease

in the army in the calendar year 1911 was only 2.66 per thousand.

As to specific diseases, we find that in 1907 there were 98 deaths from typhoid fever, in 1912 only 4 deaths from this disease. Pneumonia claimed 328 victims in 1907, and only 57 in 1912; and malaria, which caused 233 deaths in 1906, caused only 20 in 1912.

Considering the death rate of the total population including the cities of Panama, Colon, and the Canal Zone, the statistics showed an equally striking betterment. The death rate per thousand in 1905 was 49.94; in 1912 it was 20.49. As regards the former scourges of the region, Dr. Gorgas reported as follows: "One case of yellow fever on a ship from Guayaquil, Ecuador, was isolated in Santo Tomas Hospital and died there on July 14th. With this exception, no case of yellow fever, plague or small-pox occurred on the Isthmus during the year" (1912).

A later report shows that the task of making ditches to drain areas where the mosquitoes breed was still under way, and that there were regions where the deadly *Anopheles*, the carrier of malaria germs, still existed in sufficient numbers to be a menace. The report tells of tests with mosquitoes stained for identification, in which the marked individuals were found at a distance of 6,000 feet, or considerably over a mile, from where they were liberated.

This fact will be of interest to the local health authorities of many regions of the temperate zone, inasmuch as there has been a prevailing opinion that a mosquito can travel but a short distance from its breeding haunts. It becomes evident

that local health boards who wish to protect their villages from invasion by the malaria-carrying mosquito must pay attention to ponds or other reservoirs of stagnant water for a radius of more than a mile.

A long time will doubtless elapse before such conditions as Dr. Gorgas brought about in the Canal Zone will obtain widely in tropical regions. Nevertheless, the object lesson has already inspired the authorities of some cities to emulation. An idea of what may be done may be gained from a special illustration given by Dr. Mears. He says:

"In a visit made in the past winter (1912) to South America, I landed in Santos, Brazil, a city of 41,000 population, and one of the best ports on the Atlantic Ocean. A few years ago this port was devastated by raging epidemics of yellow fever. To such an extent did the disease prevail that vessels coming into the port lost in several instances, and very quickly, their entire crews from the disease, officers and men, before they could be unloaded. It was told of one instance in which a vessel lay anchored in the harbor for a period of eighteen months undischarged, with cargo perishing in the hold.

"Inspired by the fact that this city was the greatest shipping port of coffee in the world, the government and municipal authorities inaugurated a system of modern hygienic improvements which banished yellow fever, converting its beautiful harbor from a home of pestilence into an attractive seaside home, with the ships of many nations unloading and loading in guaranteed security

alongside of its commodious and well-arranged quays."

Such an illustration presents in a vivid light the enormous economic importance of these newest triumphs of medical science. The conquest of malaria, yellow fever, plague, and typhoid fever will not only metamorphose the conditions of life for the present residents of the tropics, but will open up vast equatorial regions that hitherto have been uninhabitable.

I think it was Dr. Ross, the discoverer of the part the mosquito plays in the transmission of the malaria germ, who suggested that the prevalence of malaria in Greece of the later period may have had a significant share in bringing about the decadence and downfall of that nation.

Whatever the validity of this specific suggestion, there can be no question that plagues of one kind and another have played important parts in national history. The banishment of the plagues must therefore have significance for mankind—for civilization itself—far beyond that attaching to the salvation of individual lives. Preventive medicine, in its present-day application, must be reckoned with as an ethnological influence of the first order.

CHAPTER III

THE DUCTLESS GLANDS AND RACIAL DEVELOPMENT

THERE is a highly authoritative tradition to the effect that a man can not, even by much thinking, add a single cubit to his stature.

This pronouncement is as true to-day, doubtless, as when it was originally made; yet it seems in a fair way to be challenged by the physicians of the near future; for, in recent times, a way has been found to add a considerable portion of a cubit to the stature of the growing child—at least, sometimes.

A child that seemingly is not growing at all has been made to take on rapid development, even adding five inches in its height in a single year. This is no matter of speculation, but the record of actual achievements, in well-authenticated cases; not guessed at, but measured with the tape line.

Parents whose children tend to be dwarfed in size are likely to note that fact with very keen interest.

A line of treatment closely similar to that which has transformed the dwarfed children into normal ones as to stature has been applied, still more recently, in the attempt to develop the mentality of children who were very backward, including some that ranked as imbeciles. And the children thus treated have shown very marked improvement in their mental processes as compared with

companions who received no treatment. It seems at least probable that a method is available whereby the mental growth of backward children may be stimulated, just as physical growth may be stimulated.

The possibilities opened up by such a treatment make strange appeal to the imagination; for heretofore the mentally defective child has presented insoluble problems for physician and teacher alike.

It would be an oversanguine interpreter who would suggest that the new treatment will in time transform dwarfs into giants and imbeciles into mental prodigies; but there does seem to be a fair prospect that it may develop many a dwarfed child into a normal one, and many a mentally defective child into a being of vastly improved mentality.

Such transformations, effected by the administration of drugs, will certainly constitute a remarkable triumph of medical science.

The new drugs which give such necromantic promise are animal extracts, prepared from some obscure glands of the sheep, the pig, or the ox. The use of such extracts constitutes one of the newest additions to the armamentarium of the physician. Drugs of this new type have many extraordinary uses in addition to the ones just suggested. As yet no one knows what may be the limits of their application. A cautious physician has suggested that these new drugs "unfold before the astonished view of the seeing eye a land of promise beside which the vast territories opened by Lister and Pasteur are destined to pale into honorable insignificance. In studying these new drugs," the same writer suggests, "and endeavoring to unravel their intricate and esoteric

mysteries, one seems ever and anon to be on the trail of the Great Secret, and in danger of losing one's mental perspective."

It is possible that this new aspect of medicine will occupy somewhat the same relative importance in the coming generation that the study of bacteria has occupied in the past generation.

MYSTERIOUS BODILY ORGANS

The obscure organs of sheep and ox which supply the new medicaments are of a type of organs known as ductless glands. That is to say, they are glands which produce secretions that are not discharged through ducts (as, for example, is the case with the salivary glands, the glands that secrete the tears, and the like), but merely exude their secretion into the blood stream or into the stream of lymph that circulates in the lymphatics. There are several of these glands, located in widely different regions of the body. A pair of them, known as the suprarenal capsules, or adrenals, are located just above the kidneys. A single gland known as the thymus is located in the chest. The thyroid gland and four small glands called the parathyroids are located in the neck. And two quite distinct glands, one known as the pituitary body and one as the pineal body, are situated within the skull, at the base of the brain.

The largest of these glands, in the human subject, are of insignificant size; and the smallest are scarcely larger than a pin head.

Yet these little structures exert an all-important influence over the activities of the body, and their maladjustment may lead to severe maladies or to

the death of the patient. Fortunately, however, as has recently been discovered, amends may be made for the injury of one of these glands by supplying the patient with medicaments composed of the corresponding glands of an animal.

NECROMANTIC SECRETIONS

It is only in recent years that the physiologists have gained an inkling as to the way in which these mysterious internal secretions operate. Now it appears that the relatively insignificant glands from which the internal secretions come have the most extraordinary effect in controlling the actions of the bodily organs.

And the most wonderful thing about it, perhaps, is the amazingly small quantity of the internal secretion that may produce a remarkable effect.

Take, for example, the secretion of the suprarenal glands or capsules, which is known as adrenalin, or epiniphrin. This substance is normally present in the body in such infinitesimal quantities that it represents only one part in one million parts of blood.

At first thought it seems inconceivable that so small a quantity of anything can have an appreciable effect. Yet in point of fact it has been found that the presence of this minute quantity of adrenalin is absolutely essential to the normal action of the body of the human or animal subject. If the suprarenal glands fail to keep up the supply, the patient suffers from a conspicuous and well-marked malady, one of the symptoms of which is a peculiar discoloration of the skin. Total suppression of the secretion—which amounts, be it remembered, to only one part in one million

of the blood under normal conditions—results in the death of the patient.

Suppose, on the other hand, that one of the ductless glands is enlarged in size, or for any reason secretes an excessive quantity of fluid. The results of this excess are no less disastrous. The most familiar illustration is furnished by cases in which the thyroid gland is increased in size, resulting in the disease known as goiter. This disease is sufficiently common to have been brought to the attention of the average reader; its prominent symptoms may include a curious and distressing protrusion of the eyeballs, and a general condition of malnutrition and nervousness, thoroughly incapacitating the patient.

A less familiar but even more striking illustration of what may result from the maladjustment of the secretion of one of the internal glands is shown in the distressing condition known as acromegaly, a state in which the head of the child becomes of relatively enormous size, whereas the mental faculties are stunted. The condition known as cretinism, in which the body is dwarfed and the extremities are enlarged, while the mental faculties are blunted, is also due to a disturbance of the internal secretions.

The gland known as the thymus, located in the chest, appears to have an extraordinary control over the growth of the child, and a retarding influence over the maturing of the functions that distinguish the adult from the child. A striking illustration of the effect was given in some experiments of Gudernatsch, who fed thymus gland to tadpoles, and noted their rapid growth and a very

marked delay in their transformation from tadpoles into frogs.

The thyroid gland, on the other hand, in the experiments of the same observer, caused the tadpoles to develop rapidly into frogs that were perfect as to all their organs, but pigmies in size.

Of even greater interest is the case of a human subject, in which the little gland known as the pineal body, already referred to as situated in the brain, had taken on an abnormal growth. The excessive secretion of this gland—which normally is no larger in size than a pea—caused the child's mind to develop in such an abnormal way that at five years of age he reasoned as would a young man, showing a particular predilection for ethics and philosophy. It is such cases as this that gave the clue for the treatment of mentally defective children with pineal extract, mention of which was made at the beginning of this chapter, and a fuller account of which will be given presently.

STRANGE MESSENGERS IN THE BODY

To gain an inkling of the full measure of mystery involved in all this, it must be understood that the secretion put out by one or another of these glands is not to be regarded as in an ordinary sense a food, which nourishes the tissues and causes them to grow and develop. It is rather to be thought of as a stimulant which, in some utterly mysterious way, causes remote organs to functionate as they would not otherwise do.

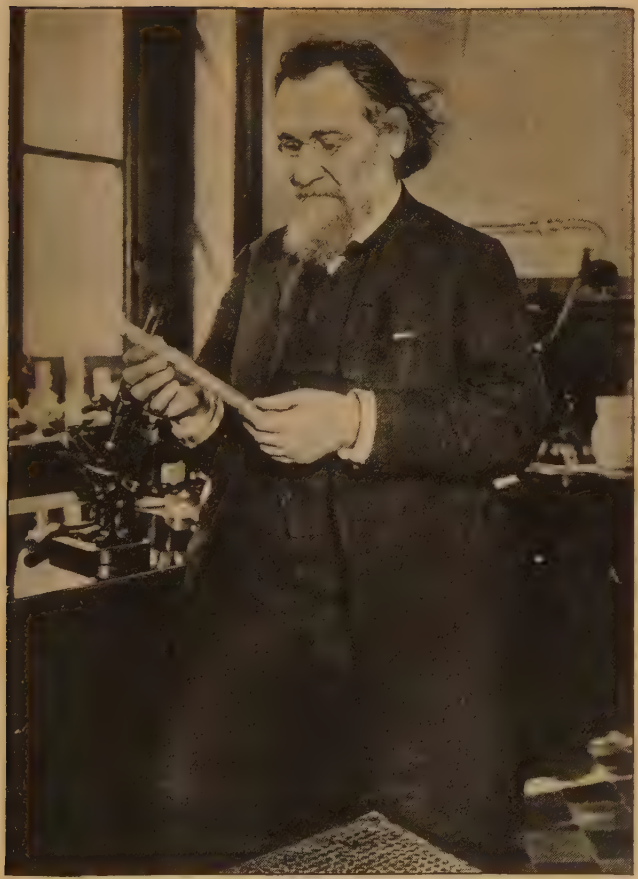
The essential principle of each internal secretion is a sort of messenger which, entering into the blood stream, is carried to one part and another of the body, and serves to put various

organs into action, somewhat as the messengers sent by a commanding general of armies may bring regiments or corps of troops into action. In each case, the messenger is insignificant; yet his message may be of the utmost importance.

Until recently it was supposed that the sole channel of communication through which the actions of different organs of the body were coordinated was the nervous system. But now we know that the internal secretions serve as direct and tangible messengers that are perhaps even more important. They supplement the work of the nervous system somewhat as the mail service supplements the telephone and telegraph in the social organism.

Because of the peculiar manner in which the internal secretions thus act to influence distant organs, they have been given the name hormones, from a Greek derivative meaning "to arouse or excite." The name was given by Professor Sterling, who first observed that the secretion of the small intestine (called *secretin*) served as a signal to the pancreas to begin putting forth its characteristic secretion, to aid in the digestion of food. More recently it has been suggested by the writer that the same one of the hormones, secretin, stimulates the tissues of the bone marrow and of the spleen also, and in so doing promotes the formation of the white and red blood corpuscles to which I ascribe an important share in the work of bodily nutrition, and likewise in protecting the individual against microbic diseases.

An interesting clue to the action of the internal secretions was gained when it was discovered that the essential principle of the suprarenal secretion



PROFESSOR ELIE METCHNIKOFF

TWO VIEWS IN THE LABORATORIES OF THE PASTEUR INSTITUTE IN NEW YORK

PREVENTIVE INOCULATION FOR RABIES AT THE PASTEUR INSTITUTE

CHAMBER FOR INCUBATION OR STERILIZATION OF BACTERIA (ABOVE), AND TAKING BLOOD FOR DIPHTHERIA-ANTITOXIN FROM THE VEIN OF A PREVIOUSLY INOCULATED HORSE

DEVELOPMENT AND ADMINISTRATION OF ANTI-TYPHOID VACCINE

A "DIFFERENTIAL COUNT" OF LEUCOCYTES OR WHITE BLOOD-CORPUSCLES UNDER THE MICROSCOPE

HANDLING ANTI-TYPHOID VACCINE IN THE LABORATORY

SAVING THE CHILDREN OF THE POOR BY
PREVENTIVE INOCULATION

(already named as adrenalin) has extraordinary power in constricting blood vessels. A bleeding surface to which adrenalin is applied is immediately blanched, through constriction of the arterioles. It is clear that adrenalin circulating in the blood must constantly tend to give tone to the arteries and arterioles.

More recent studies, however, suggest that this action is only a subordinate one; and that a vastly more important function is subserved by the secretion of the suprarenal in facilitating the taking up of oxygen by the blood in the lungs. This aspect of the subject has been chiefly studied by Dr. Sajous, who believes that the suprarenal bodies act in harmony with the thyroid apparatus and the pituitary body (in the brain) both in regulating the tone of the circulatory apparatus and the heart and in determining the taking up of oxygen by the blood, and, ultimately, the burning of the oxygen in the tissues, which is a fundamental process of all vital activities.

When the glands making up the so-called adrenal system fail to operate in harmonious coalition, or for any reason produce their secretions in sufficient quantity, the heart and arteries fail to work properly, the blood is not adequately aerated, and the tissues in general suffer from deficient oxidation. Under such circumstances, the body is ill-nourished. In the case of a child, growth is retarded. With the adult, there is a condition of malnutrition, languor, nervousness, and peculiar susceptibility to disease. Through defective oxidation, there may be a tendency to the storing up of fat in the body, even tho the system is ill-nourished.

It is in such cases that thyroid extract may be given to reduce obesity. But this treatment should never be undertaken except under guidance of a skilled physician, who makes sure of the diagnosis.

FUNCTIONS OF THE THYROID

Among the most curious physiological experiments ever performed are those in which young tadpoles are fed with fragments of thyroid glands. The results are spectacular; for the young tadpole, instead of continuing to grow and retaining the form of a tadpole for several months, is transformed very soon into a frog. If the thyroid feed was used when the tadpole was very young, the frog into which it develops must be no larger than a fly. Yet the prematurely developed tadpole is a mature frog, differing in no respect except size from its parent.

The thyroid gland which, when fed to the tadpole, produces this remarkable result is an organ common to animals and man; and it makes no difference whether the particular specimen fed the tadpole is supplied by the glands of an ox, sheep, pig, or some other animal. The growth-inhibiting and the maturity-promoting qualities of the gland are found in all alike.

Another experiment equally interesting but complementary in character is made by removing the thyroids from a young tadpole. The creature thus operated upon lives a long time and grows to large size, but remains always a tadpole. Left to itself and given an ordinary diet, it will never change into a frog. And yet, late in life, this tadpole may be made to undergo the transformation if it is fed with fragments of thyroid glands.

These striking laboratory experiments after all only duplicate experiments that Nature makes now and again with the human subject. Reference has been made to the condition known as cretinism, in which the body and mind of a child fail to develop normally, so that the individual may remain dwarfed in body and in mind after reaching what are ordinarily years of maturity. This child-dwarfism is often due to a lack of normal development of the thyroid gland; and, if taken in time, such cases may often be enormously benefited by administering to them a thyroid extract, usually prepared from the glands of sheep or pigs. Some very remarkable transformations of cretins into relatively normal children have been observed under this treatment.

Again adults sometimes suffer from failure of the thyroid gland to produce a supply of its normal secretions, with the result that their entire personalities, physical and mental, appear to be transformed. In severe cases, a condition of myxedema occurs, in which marked obesity develops, with thickening and roughening of the skin and such distortion of the features as to make the face of the sufferer seem a caricature of its former appearance. Meantime the mind may become so dulled as to simulate imbecility or dementia.

These patients may respond very promptly to thyroid extracts, losing weight rapidly, regaining a normal facial expression and being restored to normal activity of mind.

Where thyroid insufficiency is less marked, there may be all manner of gradation of symp-

toms. Many persons suffer from this condition of so-called hypo-thyroidism without suspecting it; and sometimes such a patient goes from one physician to another and receives treatment for many symptoms before the true state of things is discovered.

I have in mind such a patient who suffered for several years from obesity, lack of energy, susceptibility to infection, and from mental hebetude amounting sometimes almost to stupor, who was restored promptly to normality of body and mind, and has continued perfectly well for many years, simply by the use of tablets of thyroid extract.

This patient takes such a tablet, containing a fraction of a grain of thyroid, after every meal; and were she to fail to do so for a few days, she would quickly revert to a condition of abnormality. On one occasion she made a tour round the world, and she took a package of thyroid tablets in each parcel of her baggage, lest shipwreck or other disaster might by any possibility deprive her of the "life savers."

There are other individuals—hundreds of thousands of them in the aggregate—whose thyroid glands are over-acting. Adolescents and adults who suffer from this difficulty are likely to be unduly nervous and excitable; they may complain of headache, backache, indigestion, palpitation of the heart. Often they have periods of depression. There may or may not be visible enlargement of the thyroid gland, which lies at the base of the neck, in front, with a lobe on either side, such enlargement being familiar under the name of goiter. In some cases, the symptoms include,

oddly enough, a characteristic bulging of the eyes, leading to the name exophthalmic goiter.

One of the most interesting and important things connected with this matter of the disturbed action of the thyroid is that it is associated with the presence in the system of iodin. It has been shown in the experiments with tadpoles that the same transformation brought about in some tadpoles by feeding thyroid may be expedited in others by giving them iodin. It is known that the thyroid gland is much richer in iodin than any other organ; and that disturbed thyroid conditions are often benefited by the administration of an iodin preparation as medicine.

Moreover it is suspected that regions in which goiter is very prevalent may be regions in which there is a shortage of iodin in the soil and water. The Appalachian region of the eastern United States, including parts of Ohio and Indiana, and the Sierra Nevada regions of the northwest, including parts of Oregon, Washington, and California, are sometimes spoken of as "thyroid belts."

I have personally observed the extreme prevalence of goiter in one region of the northwest where local physicians assured me that practically half the women suffered from thyroid disturbances.

In one region in Ohio, goiter is so prevalent that some physicians have adopted the practice of giving a course of treatment with an iodin preparation to girls in the public schools for a short period in the spring and fall, and they report a marked decrease in the incidence of goiter among the girls so treated.

WONDERS OF THE NEW MEDICATION

It is much too early to predict the ultimate place of the hormones in the equipment of the physician. But results already obtained show that these agents occupy a position by themselves, and can accomplish things that hitherto have seemed to lie beyond the reach of medication. Of these things, doubtless the stimulation of physical and mental growth may be considered for the time being the most remarkable; or at least the phenomenon having the greatest popular interest. For the world is full of dwarfed bodies and piteously undeveloped minds; and until very recently the thought of remedying these conditions by specific medication seemed but a visionary dream. Now, however, the hormones point the way to magical feats of transformation.

A striking case was shown before the Paris Academy of Medicine a few years ago by Dr. Voronoff, whose work has more recently gained great publicity. In this case the child suffered both mentally and physically; its development having ceased as a sequel of scarlet fever. The condition was believed to be due to a lack of secretion of the thyroid and its allied glands. So a portion of the thyroid gland of a monkey was transplanted into the neck of the child. According to the report there was almost immediate improvement in the condition of both body and mind of the patient. Previously the child had been apathetic and stupid. He now became active and quick-witted.

Thus a being seemingly condemned to dwarfdom and imbecility is restored to normality of body and mind; the transformation being effected

through the agency of a small glandular structure taken from the body of a monkey. I cite this case with the express proviso that I have no first-hand knowledge as to its authenticity.

If authentic, this case (and allied ones in which other glands are alleged to have been similarly transplanted) is doubly remarkable because it has hitherto proved impossible to transplant tissue of any kind from one animal to another animal of a different species. That the thyroid gland of the monkey, once transplanted, should have the observed influence is remarkable enough, to be sure, but perhaps not surprizing in the light of our knowledge of other cases. For, as previously suggested, extracts of the thyroid gland have already taken their place as remedies of established value.

It is not yet time for the ultimate verdict on such operations and on the allied ones of the Viennese surgeon who ties the spermatic ducts and gives X-ray treatment to ovaries to stimulate hormonic activities of the gonads in the hope of rejuvenating senescent individuals.

As regards the physical growth of children, however, the best results hitherto reported have been attained through use of the thymus gland rather than the thyroid; or by a combination of glandular extracts. This is in accord with the experiments already cited in which tadpoles were made to grow rapidly by feeding with thymus. With older children, however, as with adults, the thyroid extract may be of great value in stimulating normal activity of the various organs. In the case of the cretin, the remedy is pituitary extract.

STIMULATING THE DEFECTIVE MIND

When direct stimulation of the mental processes is in question, it would appear that the best results are sometimes to be expected from the use of a quite different gland, namely, the pineal body; the tiny organ situated in the brain that is believed to be a rudimentary or vestigial structure, representing what was a functional eye in some lower orders of creatures that were our remote ancestors.

In the light of recent experiments, it is of interest to recall that the French philosopher Descartes, more than two centuries ago, made the curious suggestion that the pineal body is the seat of the soul.

The most important tests that have been made of the pineal gland, as a promoter of mental growth, are those reported by Drs. Dana and Berkeley. They were led to take up the matter through consideration of a case reported by a German physician in which a boy of five and a half years had the size and appearance of a normal boy of twelve or thirteen. This child had a low-pitched voice, and was mentally precocious; "he is said to have asked many questions about the condition of the soul after death, and on another occasion remarked reflectively: 'It is odd how much better I feel when I let the other children play with my toys than when I play with them myself.'"

The child died when five and one-half years old, and an autopsy revealed a tumor of the pineal gland. It seemed reasonable, therefore, to assume that the precocious mental development of the child had been due to an excessive activity of this organ. If such was really the fact, the physicians

argued, cases of defective mentality might be due to subnormal action of this gland; and perhaps the defective minds might be stimulated by the administration of a drug made from the pineal gland of an animal.

Acting on this supposition, the experimenters secured the pineal glands of calves and afterwards of young bullocks, and caused them to be dried and ground into a powder, which was then placed in a capsule, to be administered by the mouth. As the medication was finally adjusted, each capsule contained the amount of pineal gland equivalent to one hundred and fifty pounds weight of the bullock. If, for example, the young bullock weighed six hundred pounds, its pineal body would be made into four capsules.

The drug was first tested by dosing young guinea-pigs, rabbits, and kittens; an equivalent number of animals not treated being always kept with the others as "controls." The result of the medication was at once surprising and gratifying. "Of eight half-grown guinea-pigs under observation for five weeks, four subjects gained thirty-six per cent. and four controls gained twenty-five in weight. Of a dozen small kittens, the subjects outgrew the controls rapidly in activity, size, intelligence, and resistance to intercurrent disease. The best control, beginning with the weight of eleven ounces, gained four ounces in two months and a half. The best subject, starting with a weight of twelve ounces, gained twelve ounces more, doubling his weight. All were fed alike."

These animals were fed with the fresh pineal glands. But the tests were continued with ten small rabbits, using the capsules of dried glands.

The results were equally gratifying. One of the subjects died by accident, and two of the controls also died; but of the survivors, in the course of five months' treatment, the subjects gained an average of forty-eight ounces each, and the controls only thirty-six ounces each. The subjects were reported as beautiful specimens, clean, active, and fat, and their growth was remarkable. One of the smaller ones trebled his weight exactly.

Such results seemed to justify the testing of the drug with human subjects. The tests were made at the Training School for Defective Children at Vineland, New Jersey, under the impartial and expert observation of Dr. H. H. Goddard. The experiments consisted of the observation of twenty-five subjects to whom capsules of pineal gland were given daily for four months, and twenty-five controls of similar mental condition who received no such treatment; all the children being, of course, under the regular dietetic and edcational routine of the institution.

To quote the record: "Of the subjects, several were congenital idiots, and these, as was anticipated, made no progress. But fourteen of the others made a gain, and the average, 65 per cent. of a year, was twice the normal, and more than twice the progress of the control children in the same period. Some of the subjects advanced eight-tenths of a year; one advanced one and eight-tenths years. This child's teacher, who had not heard of the pineal gland experiment, came voluntarily and asked what new medicine the child was getting—as his progress was quite unusual."

It should be added that these results were considered as by no means conclusive.

A similar test was made with another group of backward children at one of the New York public schools. The capsules were kept at the school, and were given to the pupils, with the consent of their parents, on school days only, for a period of five months. A majority of the children tested—about sixteen in all—made greater or less response; and in some cases the progress was very notable. Of one such case the teacher, Miss Young, reported as follows: "A year ago she could not write a word or sentence without help. Now she writes simple sentences in language without any help. In September she could not spell a word. At the end of January in a spelling review of forty words she spelled thirty-eight correctly. She reads much better than she did, and can now do simple combinations in number. She has always tried very hard to sew and since January first has completed a sofa cushion in cross-stitch embroidery. I am very proud of Hannah's improvement."

The physicians who directed the treatment, and the teacher, were at one in ascribing the progress definitely to the capsules of the pineal gland. With all due allowance for the natural enthusiasm of pioneer experimenters, it can hardly be denied that the observations are at least thought-provocative.

Cases in private practise gave equally striking results. Dr. Berkeley reports a clinic case, for example, in which a boy of seven years that "had never said any connected or intelligent words," and that had the appearance and habits of an

imbecile was so transformed in two months' treatment with the pineal gland (no other remedy being employed) that his changed facial expression and manner were noticeable at a glance; his habits had become entirely correct; and he could understand and answer simple questions, and had acquired between fifty and one hundred words.

Surely we must agree with the experimenter that such cases "justify in some measure the faith that is in us that pineal gland is going to be a remedy of great value in some cases of retarded mentality in children." Just what are its limitations and what the range of its possibilities are questions that must await the verdict of future tests.

Meantime it is of peculiar interest to record that Dr. Berkeley has made tests to see whether the drug which thus accelerates the sluggish action of the brain of the retarded child may not also serve to arrest or delay certain cases of premature breakdown of the mental powers in old age. He reports that in cases of premature mental failure without distinct organic cause, the drug has proved of great value with about a dozen patients with whom it has received a fair trial. Some of these patients, he says, decline positively to be without the drug; and he adds "judging by their cheerfulness and mental activity while under its influence, I must conclude that it definitely stimulates the aging brain to the faster chemistry of younger days."

A drug that promises to stimulate the mental growth of defective children and to retard the onset of senility may surely be considered worthy of careful investigation by the medical profession.

GUARDING THE BODY AGAINST DISEASE

The central link of association between the different hormones is found in the fact that they all, apparently, have to do, in one way or another, with matters of bodily nutrition. They are not themselves foods, but they assist in the digestion and assimilation of foods; and they exert curious selective influence in determining what particular organs of the body shall be stimulated as to their life-processes.

Now it appears, according to the newest theories, that there is the closest possible association between bodily nutrition and immunity to bacterial diseases. In the theory of immunity, published in 1914 under title of the Protemorphic theory, I have argued that the activities of the body in fighting off virulent bacteria are part and parcel of the more general activities that have to do with the digestion and assimilation of protein foods (milk, eggs, meat, etc.). In other words, according to this view, immunization against disease is merely one aspect of the great universal problem of bodily nutrition.

If, then, defense against bacterial disease is a matter of nutrition; and if the hormones or internal secretions largely control nutrition, it would seem to follow that there should be a close relation between the "endocrine balance" and susceptibility to contagious diseases. In point of fact, such an association has for some time been recognized. It is a matter of observation, for example, that persons suffering from a deficient supply of thyroid secretion are peculiarly susceptible to contagious diseases. Recently Dr. Sergent has attempted to prove that defective action of the su-

prarenal glands may be observed in all infectious diseases, as well as in all severe intoxications.

He makes a close association, for example, between such defects and the symptons of typhoid fever; and he advocates the use of adrenal preparations in the treatment of all cases of typhoid.

Dr. Harrower adds that adrenal preparations are always indicated in the treatment of Asiatic cholera, plague, and similar serious toxic infections. Adrenalin has also been used, apparently with good effects, in the treatment of snake bite. It is reported to overcome shock at once, and seemingly to arrest the poisonous action of the venom upon the organism at large.

It is claimed that persons suffering from one of the most hopeless forms of insanity, known as *dementia praecox,* are found to have adrenal glands showing notable variation from the normal in weight and size. In seven out of eight cases of this disease observed by Drs. Dercum and Ellis, the thyroid also was under weight. Here, then, is a clue to the possible treatment of a common form of insanity which hitherto has proved altogether intractible. In this connection it is of peculiar interest to note that most cases of this form of insanity die ultimately of tuberculosis. We are justified in assuming that the defective supply of internal secretions has at least a share in rendering the patient susceptible to the attacks of the tubercle germ.

It remains to note that other workers in this field are attempting to trace a relation between abnormalities of the ductless glands and the development of cancer. "Errors in nutrition," says Dr. Harrower, "whether local or general, are the

factors which permit of the implantation of cancer cells and the growth of the tumor. The ductless glands preside over nutrition. Hence it is not unreasonable to suppose that there may be some relation between disturbancies of the hormones balance and cancer, and, too, that there may be some prospects of therapeutic value in the treatment of this disease by organotherapy. As yet very little is known, but it seems that another door has just been opened a crack, and shortly we may expect to hear of some of the interesting things that lie just beyond that door."

As illustrating the curious interrelations of the different hormones, which sometimes seem to antagonize or neutralize one another, we may note observations alleged to reveal the effect of the intestinal hormone called secretin on more than two hundred cases of diabetes and of Graves' disease, to which there were symptoms of auto-intoxication from improper assimilation of proteid (nitrogenous) foods. It appeared that secretin counteracted the toxic effects, by stimulating the production of red and white blood corpuscles, which are seemingly the great bodily defenders against toxins of every kind.

These observations constitute another link in the chain of association already established between the hormones and virulent diseases in general, including typhoid and consumption on one hand, and cancer and insanity on the other.

HEREDITY AND PRENATAL INFLUENCE

But even this does not take the full measure of the influence ascribed to the hormones. Their aid has been invoked in the clearing up of several

biological and physiological mysteries in addition to those already cited. These mysteries include the moot problem of the transmission of acquired characters in heredity; the equally disputed question of the influence of the mother over the unborn child; and the ever-recurring problem of the determination of sex. All these are questions of vital interest to every one.

As to the problem in heredity, many biologists have ardently disputed the possibility of the transmission of acquired traits, because they were unaware of the existence of any mechanism through which altered conditions of the parental body could bring about a corresponding condition in the hereditary factors in the germ-plasm. But now that we know that the activities of many organs are associated with the giving out of hormone-messengers, which produce a stimulative effect on tissues selected by themselves, it seems at least possible that similar chemical agents may act selectively on a portion of the germ-plasm by stimulating its development.

It is at least conceivable, for example, that the development of the muscular tissues or the brain tissues of an individual may be accomplished by the giving out of hormonic secretions that exert a selective and stimulative influence on the factors in the germ-plasm that will account for the development of the muscular system or the brain system in the offspring.

That such a relation actually exists, awaits demonstration; but analogical reasoning gives it at least a degree of plausibility, and furnishes a measure of support for the contentions of those biologists who feel that the efforts of the indi-

vidual organism are not without their influence in developing the race through a transmissible effect on the progeny.

The same line of reasoning applies to the question of the prenatal influence of mother over the unborn child. The popular mind has always believed in such influences; the scientific physician has for the most part repudiated them, chiefly on the ground that he could point to no mechanism through which such transmission could take place. But there as before the hormones supply an answer. Suppose, for example, that an expectant mother receives a severe shock,—say from freight through witnessing an accident. According to Dr. Cannon's experiments, such an emotion will cause an excessive secretion of adrenalin, with consequent spasm of the arteries and increase of sugar in the blood. We can scarcely doubt that the blood of the unborn child will be similarly affected, and that the presence of the excess of hormones may result in profoundly changing its conditions of nutrition.

Here, as before, the precise tracing of results awaits further experiment and observation; but in general it may safely be said that the new knowledge tends in some measure to corroborate and confirm the old household belief, as against the skepticism of men of science,—skepticism, it may be added, which the present writer has always shared.

THE DETERMINATION OF SEX

As to the all-important matter of the determination of sex, there is a certain amount of recent evidence, involving the hormones, that is at least highly suggestive.

Here again the men of science are skeptical, seemingly not without cause; yet there are skilful and cautious physicians who are able to cite considerable lists of cases in which they believe the giving of adrenalin to expectant mothers has resulted in the birth of male children.

Far larger series of cases must be reported before so amazing a claim can be taken very seriously; but the claim finds a certain measure of theoretical support in the recognized relation between various of the hormones and the sex characteristics. Should it be proved that these agents, which are known to affect so profoundly the development of the child after birth, and indeed throughout life, have also a share in the determination of sex itself, the hormones must be given a place of unchallenged preeminence in the eyes of the physician and layman alike.

Agents that may more or less plausably be supposed to have a share in determining the hereditary transmission of characters, in controlling the relations of mother and unborn child, and in determining sex; and which are known to have a controlling influence over the development of both body and mind of the growing child; to control also the conditions of nutrition of the adult, involving his susceptibility to disease; and which appear ultimately to have to do with the onset or the retardation of the symptoms of old age,—such agents, assuredly, yield to no others in their universal interest and appeal.

The name hormones, by which these mysterious agents are technically known, is so new that it is unfamiliar and perhaps seems technical and repellant; but we may safely predict that it will

become a household word in the course of the coming decade. The word "chalones" should also be recalled, as applied to hormones that are supposed to exert an inhibiting action, instead of a stimulative one, on distant organs.

BY WAY OF SUMMARY

In addition to the ductless glands, certain other organs, notably some glands of the intestinal tract, the reproductive glands, and the pancreas produce important hormones. It is suspected that similar secretions may be produced by all organs and cells of the body; and the present writer has urged that the blood corpuscles and the mother-cells that produce them are important members of the hormone system—or endocrine system as it is otherwise designated.

A great deal remains to be learned about the hormones. Present knowledge is strictly provisional. From a popular standpoint, the most spectacular features of the subject, so far as known, attach to the thyroid, the suprarenal, and the pituitary gland. These three organs are somewhat complementary in their operations. No one of them can altogether take the place of another; and in some respects their mutual relations appear antagonistic; as, for example, with regard to the effect on the heart, an excess of thyroid fluid causing increased activity, whereas suprarenal and pituitary secretions increase the tone of the vascular system and lower the heart beat. Pituitary extract in particular is frequently given nowadays by surgeons to patients about to undergo an operation, to support the heart and prevent shock.

To be quite accurate it must be added that both the suprarenal capsules and the pituitary body are complex organs, different portions of which produce secretions having different physiological measure; but details as to this are rather too complicated to be of interest to the general reader. Suffice it to say that it is only the outer layer, or cortex, of the suprarenals that produces the vascular tonic; and only the posterior lobe of the pituitary, the secretion from which has a similar function. Meantime the anterior lobe of the pituitary produces a secretion which appears to be associated with bodily growth.

The pituitary body as a whole is only a pigmy organ. It is lodged in a little cavity at the base of the brain. For generations anatomists observed it without having the remotest notion as to its function. But now it appears that the anterior portion of it is able to control in the strangest ways the handling by the organism of the lime salts that are the chief constituents of the bones. The little group of cells in the tiny gland up there in the brain is like the general staff of an army, controlling the actions of millions of men. If the pituitary is active, the lime salts dissolved in the blood are directed to the bones and incorporated into their substance so that the organism grows, and may even assume the proportions of a giant.

Even if the individual is adult, and beyond the age of growth, the bony structure may be very conspicuously modified,—the head enlarged, jaws broadened and made to protrude, and the form of the hands and feet conspicuously modified. This condition of so-called acromegaly constitutes a

deformity as conspicuous in its way, and in some respects resembling the deformity of myxoedema, due to thyroid disturbance, already referred to.

In case of insufficiency of the pituitary secretion, a general disturbance of another type may be felt, characterized by infantile development. In case of a boy, the skeleton fails to develop along normal lines, the bones seem light and the extremities tapering. In other cases, however, there is skeletal overgrowth, with marked tendency to corpulence. If the subject is already adult at the time when the gland ceases to function properly, the tendency to obesity may be the most marked symptom, together with lassitude of mind and functional disturbances showing lack of vigor.

As in the case of thyroid disturbances, there are all gradations between the extremes; and it is only in very recent years that physicians have learned to recognize the less severe types of disturbed conditions as due to maladjustment in the secretions of these glands.

Enough has been said to make it clear that these curious little ductless glands play a part in the functioning of the organism altogether disproportionate to their size. They are, in a word, the arbiters of the functioning of the entire organism. A maladjustment in the structure of one of these little glands may determine whether a certain infant shall become a dwarf or a giant; whether the individual shall be an imbecile or a person of full normality and vigor. Later in life, similar maladjustments may determine whether the individual shall be in normal health or shall suffer from an almost endless variety of organic and functional disturbances.

Not only the physical organism but the mental and emotional personality of the individual appears to be dominated by these small and physically unimportant organs, for the most part stored away in obscure corners of the body, yet maintaining arbitrary control over every cell in the organism.

Very recently it has come to be surmised by more imaginative physiologists that organs which thus dominate the individual may also have a potent influence in determining the characteristics of various groups of individuals making up successive races of men. The thought naturally suggests itself that prominent racial characteristics may be determined by the average balance between the activities of thyroid, and pituitary glands among individuals making up the race.

Take, for example, the Mediterranean races. They are conspicuously short of stature; mature early; and are of emotional temperament. The characteristics, physical and mental, suggest a preponderant thyroid influence.

Considering what is known about the relation between the presence of iodin and thyroid activity, it is perhaps permissible to assume that members of the Mediterranean race, living so largely upon products of the sea, may have a larger proportion of iodin in their food than a people living in the interior of a Continent. The chief source of commercial iodin, as is well known, is kelp prepared from seaweed. There are traces of iodin everywhere, but the habitats of iodin-bearing sea weeds vary. It is said that the western coast of Ireland and the coast of Brittany furnishes exceptional supplies. Conceivably the presence of iodin in

the waters, and therefore in the bodies of the sea creatures largely drawn upon for food, in these regions may in a measure account for the proverbial mercurial temperament of the inhabitants of Ireland and of Brittany, comparable to the temperament of the Mediterranean races rather than to that of the inhabitants of the neighboring island of England.

The stature, slow development, and phlegmatic temperament of the Englishman, on the other hand, suggest a predominant pituitary rather than thyroid influence. And it will be recalled that the upper class Englishman in particular, is notoriously an eater of mutton and beef rather than of sea foods. Not being a Catholic, he does not habitually eat fish even on Friday, as does the Irishman.

One other suggestive illustration must suffice,—the case of Japanese. Here we have small stature and artistic temperament suggesting thyroid activity, in a people where iodin-bearing sea products are staples; combined with a slowness of heart suggesting full activity of the suprarenal glands and posterior lobe of the pituitary.

Just what chemical conditions of soil and water conduce to exceptional activity of suprarenal and pituitary glands, present day science has not determined. It is perhaps not over hazardous to predict, however, that the ethnologist of the future will be aided in his classification of races—hitherto at best a rather unsatisfactory performance—by knowledge supplied him by the physiologist concerning the relative status among different groups of peoples of the members of the thyroid-suprarenal-pituitary triumvirate.

CHAPTER IV

ARCHEOLOGY AND THE SCOPE OF HISTORY

THE AGE OF THE WORLD

WHEN Queen Victoria came to the throne, the year 4004 B. C. was accepted, in all sobriety, as the date of the creation of the world.

Perhaps no single statement could more vividly emphasize the change in the point of view from which scholars regard the chronology of ancient history than the citation of this indisputable fact. To-day, tho Bibles are still sometimes printed with the year 4004 B. C. in the margin of the first chapter of Genesis, no scholar would pretend to regard this reference seriously.

On the contrary, the scholarship of to-day regards the fifth millennium B. C. as well within the historical period for such nations as the Egyptians and the Babylonians. It has come to be fully accepted, that when we use such a phrase as "the age of the world" we are dealing with a period that must be measured not in thousands but in millions of years; and that to the age of man must be allotted a period some hundreds of times as great as the five thousand and odd years allowed by the old chronologists.

This changed point of view, needless to say, has not been reached without ardent and even bitter controversy. Yet the transformation is un-

equivocal; and the revised conception no longer seems to connote the theological implications that were at first ascribed to it.

It has now become obvious that the data afforded by the Hebrew writings should never have been regarded as sufficiently accurate for the purpose of exact historical computations: that, in short, no historian working along modern scientific lines could well have made the mistake of supposing that the geneological lists of the Pentateuch afforded an adequate chronology of world-history. But it should not be forgotten that to many generations of close scholarship these geneological lists seemed to convey such knowledge in the most precise terms, and that at so recent a date as, for example, the year in which Queen Victoria came to the throne, it was nothing less than rank heresy to question the historical accuracy and finality of chronologies that had no other source or foundation.

THE WIDE SCOPE OF ARCHEOLOGY

This changed point of view regarding the chronology of history may without hesitation be ascribed to the influence of evidence obtained in a single field of inquiry, the field, namely of Archeology.

No doubt the evidence as to the age of the earth and as to the antiquity of man was gathered by a class of workers not formally included in the ranks of the archeologists: workers commonly spoken of as paleontologists, anthropologists, ethnologists, and the like. But the distinction scarcely connotes a real difference. The scope of the archeologist's studies must include every de-

partment of the ancient history of man as preserved in antiquities of whatever character, be they tumuli along the Baltic, fossil skulls and graven bones from the caves of France, the flint implements, pottery, and mummies of Egypt, tablets and bas-reliefs from Mesopotamia, coins and sculptures of Greece and Rome, or inscriptions, waxen tablets, parchment rolls, and papyri of a relatively late period of classical antiquity.

If at one time the monuments of Greece and Rome claimed the almost undisputed attention of the archeologist, that time has long since passed. For the most important historical records that have come to us in the past half century we have to thank the Orientalist, tho the classical explorer has been by no means idle.

It is the purpose of the present chapter to point out in general terms the import of the message of archeological discovery in the recent epoch in its bearings upon the great problems of world-history.

Perhaps this purpose may be best attained if we take up these problems one after another, contrasting in each case the old point of view with the new, and briefly outlining the evidence on which the present decision rests. This, of course, is not the place for details as to the archeological discoveries involved. Here we have to do with only the discoveries that have led to broad historical generations regarding such subjects as the Antiquity of Man, the Antiquity of Culture, the Chronology of Ancient History, the Status of Bible History, the Credibility of Early Classical History, the Origin and Development of the Art of Writing, and the Evolution of the Fine Arts.

With regard to the changed conception as to the

age of the earth, it is necessary to recall that this came about through the efforts of the paleontologists and geologists, with only indirect or incidental aid from the archeologists.

The reform movement began actively with James Hutton in the later years of the 18th century, and was forwarded by the studies of William Smith in England and of Cuvier in France; but the really efficient champion of the conception that the earth is very old was Sir Charles Lyell, who published the first edition of his epoch-making *Principles of Geology* only a few years before Queen Victoria came to the throne.

Lyell demonstrated to the satisfaction—or, perhaps it should rather be said, to the dissatisraction—of his contemporaries that the story of the geological ages as recorded in the strata of the earth becomes intelligible only when vast stretches of time are presupposed.

Of course the demonstration was not accepted at once. On the contrary, the champions of the tradition that the earth was less than six thousand years old held their ground most tenaciously, and the earlier years of the Victorian Era were bitter years of controversy. The result of the contest was never in doubt, however, for the geological evidence, once it had been gathered, was unequivocal; and by about the middle of the century it was pretty generally admitted that the age of the earth must be measured by an utterly different standard from that hitherto in vogue.

This concession, however, by no means implied a like change of view regarding the age of man. A fresh volume of evidence required to be gathered and a fresh controversy to be waged, be-

fore the old data for the creation of man could be abandoned. Lyell again was in the forefront of the progressive movement, and his work on *The Antiquity of Man*, published in 1863, gave currency for the first time to the new opinions.

The evidence upon which these opinions were based had been gathered by such anthropologists as Schmerling and Boucher de Perthes, and it had to do chiefly with the finding of implements of human construction associated with the remains of extinct animals in the beds of caves, and with the recovery of similar antiquities from alluvial deposits the great age of which was demonstrated by their depth.

Every item of the evidence was naturally subjected to the closest scrutiny, but at last the conservatives were forced reluctantly to confess themselves beaten. Their traditional arguments were powerless before the array of data marshalled by the new science of prehistoric archeology.

Looking back even at the short remove of a half century, it is difficult to appreciate how revolutionary was the conception of the antiquity of man thus inculcated. It rudely shocked the traditional attitude of scholarship towards the history of our race. It disturbed the most cherished traditions and the most sacred themes. It seemed to threaten the very foundations of religion itself.

Yet the present generation accepts the antiquity of man as a mere matter of fact. Here, as so often elsewhere, the heresy of an elder day has come to seem almost an axiomatic truth.

This is not the place to suggest, even in the roughest outline, the social, ethical, and religious

implications that were bound inseparably with the revolutionary conception as to man's creation. It may not be amiss to add, however, that in establishing the broad facts of man's antiquity, prehistoric archeology as yet falls short of the power to estimate, even roughly, in terms of years the periods with which it deals; and history, in the narrow sense, can hardly be said to exist without chronology.

On the other hand, some of the most remarkable advances for which the historian must thank the archeologist have to do with the chronology of the early periods of Oriental history. Indeed, the greatest feat of the archeologist has been the opening up to our observation, and the bringing within the scope of the historian, of long periods which, without his aid, must still have belonged to the vague realms of the prehistoric.

EARLY ORIENTAL HISTORY

If we go back in imagination to the beginning of the Victorian Era and ask what was then known of the history of Ancient Egypt, Mesopotamiy, and Asia Minor, we feel ourselves confronted with a startling paucity of knowledge.

The key to the mysteries of Egyptian history had indeed been found, thanks to the recent efforts of Thomas Young and Champollion, but the deciphering of inscriptions had not yet progressed far enough to give more than a vague inkling of what was to follow. It remained, then, virtually true, as it had been for two thousand years, that for all that we could learn of the history of the Old Orient in pre-classical days, we must go solely to the pages of the Bible and to a few

classical authors, notably Herodotus and Diodorus. A comparatively few pages summed up, in language often vague and mystical, all that the modern world had been permitted to remember of the history of the greatest nations of antiquity.

To these nations the classical writers had ascribed a traditional importance, the glamour of which still lighted their names, albeit revealing them in the vague twilight of tradition rather than in the clear light of history.

It would have been a bold, not to say a reckless, dreamer who dared predict that any future researches could restore to us the lost knowledge that had been forgotten for more than two millenniums. Yet the Victorian Era was scarcely ushered in before the work of rehabilitation began, which was to lead to the most astounding discoveries and to an altogether unprecedented extension of historical knowledge.

EXCAVATIONS AT NINEVAH

Early in the forties the Frenchman Botta, quickly followed by Sir Henry Layard, began making excavations on the site of ancient Nineveh, the name and fame of which were a tradition having scarcely more than mythical status. The spade of the discoverer soon showed that all the fabled glories of the ancient Assyrian capital were founded on realities, and evidence was afforded of a state of civilization and culture such as few men supposed to have existed on the earth before the Golden Age of Greece.

Not merely were artistic sculptures and basreliefs found that demonstrated a high development of artistic genius, but great libraries were

soon revealed,—books consisting of tablets of various sizes, or of cylinders of the same material, inscribed while in the state of clay with curious characters, which became indelible when baking transformed the clay into brick.

No one was able to guess, even in the vaguest way, the exact interpretation of these odd characters; but, on the other hand, no one could doubt that they constituted a system of writing, and that the piles of inscribed tablets were veritable books. There were numerous skeptics, however, who did not hesitate to assert that the import of the message so obviously locked in these curious inscriptions must forever remain an absolute mystery.

Here, it was said, were inscriptions written in an unknown character and in a language that for at least two thousand years had been absolutely forgotten. In such circumstances nothing less than a miracle could enable human ingenuity to fathom the secret.

Yet the feat pronounced impossible by mid-century skepticism was accomplished by contemporary scholarship, amidst the clamor of opposition and incredulity. Its success conveys at once a warning to those doubters who are always crying out that we have reached the limitations of knowledge, and an encouragement and stimulus to would-be explorers of new intellectual realms.

HOW THE INSCRIPTIONS WERE READ

In a few words the manner of the discovery was this. It appears at a glance that the Assyrian written character consists of groups of horizontal, vertical, or oblique strokes.

The characters thus composed, tho so simple as

to their basal unit, are appalingly complex in their elaboration. The Assyrians, with all their culture, never attained the stage of analysis which demonstrates that only a few fundamental sounds are involved in human speech, and hence that it is possible to express all the niceties of utterance with an alphabet of little more than a score of letters.

Halting just short of this analysis, the Assyrian ascribed syllabic values to the characters of his script, and hence, instead of finding twenty odd characters sufficient, he required about five hundred.

There was a further complication in that each one of these characters had at least two different phonetic values; and there were other intricacies of usage which, had they been foreknown by inquirers of the middle of the 19th century, might well have made the problem of decipherment seem an utterly hopeless one.

Fortunately it chanced that another people, the Persians, had adopted the Assyrian wedge-shaped stroke as the foundation of a writing system, but, making that analysis of which the Assyrians had fallen short, had borrowed only so many characters as were necessary to represent the alphabetical sounds. This made the problem of deciphering Persian inscriptions a relatively easy one.

In point of fact this problem had been partially solved in the early days of the 19th century, thanks to the sagacious guesses of the German philologist Grotefend. Working with some inscriptions from Persepolis which were found to contain references to Darius and Xerxes, Grote-

fend had established the phonetic values of certain of the Persian characters, and his successors were perfecting the discovery just about the time when the new Assyrian finds were made.

It chanced that there existed on the polished surface of a cliff at Behistun in Western Persia a tri-lingual description which, according to Diodorus, had been made by Queen Semiramis of Ninevah, but which, as is now known, was really the work of King Darius.

One of the languages of this inscription was Persian; another, as it now appeared, was Assyrian, the language of the newly discovered books from the libraries of Ninevah. There was reason to suppose that the inscriptions were identical in meaning; and fortunately it proved, when the inscriptions were made accessible to investigation through the efforts of Sir Henry Rawlinson, that the Persian inscription contained a large number of proper names.

It was well known that proper names are usually transcribed from one language into another with a tolerably close retention of their original sounds. For example, the Greek names Ptolemaios and Kleopatra were incorporated into the Egyptian language and appeared regularly in Egyptian inscriptions after Alexander's general became King of Egypt. Similarly, the Greek names Kyros, Darios, and Xerxes were as close an imitation as practicable of the native names of these Persian monarchs.

Assuming then, that the proper names found in the Persian portion of the Behistun inscription occurred also in the Assyrian portion, retaining virtually the same sound in each, a clue to the

phonetic values of a large number of the Assyrian characters was obviously at hand.

Phonetic values known, Assyrian was found to be a Semitic language cognate to Hebrew.

THE NEW SCIENCE OF ASSYRIOLOGY

These clues were followed up by a considerable number of investigators, with Sir Henry Rawlinson in the van. Thanks to their efforts, the new science of Assyriology came into being, and before long the message of the Assyrian books had ceased to be an enigma.

Of course this work was not accomplished in a day or in a year, but, considering the difficulties to be overcome, it was carried forward with marvellous expedition.

In 1857 the new scholarship was put to a famous test, in which the challenge thrown down by Sir George Cornewall Lewis and Ernest Renan was met by Rawlinson, Hincks, Oppert, and Fox Talbot in a conclusive manner. The skeptics had declared that the new science of Assyriology was itself a myth: that the investigators, self-deceived, had in reality only invented a language, and read into the Assyrian inscriptions something utterly alien to the minds of the Assyrians themselves. But when a committee of the Royal Asiatic Society, with George Grote at its head, decided that the translations of an Assyrian text made independently by the scholars just named were at once perfectly intelligible and closely in accord with one another, skepticism was silenced, and the new science was admitted to have made good its claims.

Naturally the early investigators did not fathom

all the niceties of the language, and the work of grammatical investigation has gone on continuously under the auspices of a constantly growing band of workers. Doubtless much still remains to be done; but the essential thing, from the present standpoint, is that a sufficient knowledge of the Assyrian language has been acquired to insure trustworthy translations of the cuneiform texts.

Meanwhile, the material found by Botta and Layard, and their successors, in the ruins of Ninevah has been constantly augmented through the efforts of companies of other investigators, and not merely Assyrian, but much earlier Babylonian and Chaldaean texts in the greatest profusion have been brought to the various museums of Europe and America.

The study of these different inscriptions has utterly revolutionized our knowledge of Oriental history. Many of the documents are strictly historical in their character, giving full and accurate contemporary accounts of events that occurred some thousands of years ago. Exact dates are fixed for long series of events that previously were quite unknown. Monarchs whose very names had been forgotten are restored to history, and the records of their deeds inscribed under their very eyes are before us,—contemporary documents such as neither Greece nor Rome could boast, nor any other nation, with the single exception of Egypt, until strictly modern times.

NEW LIGHT ON ANCIENT CHRONOLOGY

There are, no doubt, gaps in the record; there are long periods for which the chronology is still uncertain. Naturally there is an increasing vague-

ness as one recedes further into the past, and for the earlier history of Chaldaea there is great uncertainty.

Nevertheless, the Assyriologist speaks with a good deal of confidence of dates as remote as 3800 B. C., the time ascribed to King Sargon, who was once regarded as a mythical person, but is now known to have been an actual monarch. Indeed, there are tablets in the British Museum labeled 4500 B. C.; and later researches, particularly those of the expedition of the University of Pennsylvania at Nippur, have brought us evidence which, interpreted with the aid of estimates as to the average rate of accumulation of dust deposits, leads to the inference that a high state of civilization had been attained in Mesopotamia at least 9,000 years ago.

While the Assyriologists have been making these astonishing revelations, the Egyptologists have not been behindhand. Such scholars as Lepsius, Brugsch, de Rouge, Lenormant, Birch, Mariette, Maspero, and Erman have perfected the studies of Young and Champollion; while at the same time these and a considerable company of other explorers, most notable of whom are Gardner Wilkinson and Professor Flinders Petrie, and still more recently Lord Carnarvon (whose discovery of the tomb of King Tut-Ankh-Amen, at Luxon, has excited extraordinary popular interest), have brought to light a vast accumulation of new material, much of which has the highest importance from the standpoint of the historian.

Lists of kings found on the temple wall at Abydos, in the fragments of the Turin papyrus, and elsewhere, have cleared up many doubtful

points in the lists of Manetho, and at the same time, as Professor Petrie has pointed out, have proved to us how true a historian that much-discussed writer was.

Manetho, it will be recalled, was the Egyptian who wrote the history of Egypt in the time of the Ptolemies. His work in the original unfortunately perished, and all that we know of it we learn through excerpts made by a few later classical writers. These fragments have until recently, however, given us our only clue to the earlier periods of Egyptian history. Until corroboration was found in the Egyptian inscriptions themselves, not only were Manetho's lists in doubt, but skepticism had been carried to the point of denying that Manetho himself had ever existed.

This is only one of many cases where the investigations of the archeologist have proved not iconoclastic but reconstructive, tending to restore confidence in classical traditions which the scientific historians of the age of Niebuhr and George Cornewall Lewis regarded with skepticism.

EGYPTIAN CHRONOLOGY

As to the exact dates of early Egyptian history there is rather more of vagueness than for the corresponding periods of Mesopotamia. Indeed, approximate accuracy is not attained until we are within sixteen hundred years of our own era; but the sequence of events of a period preceding this by two thousand years is well established, and the discoveries of Professor Petrie in particular carry back the record to a period which can not well be less than five thousand, perhaps not less than six thousand, years B. C.

Both from Egypt and Mesopotamia, then, the records of the archeologist have brought us evidence of the existence of a highly developed civilization for a period exceeding by hundreds, perhaps by thousands, of years the term which had hitherto been considered the full period of man's existence.

We may note at once how these figures disturb the historical balance.

If our forerunners of eight of nine thousand years ago were in a noonday glare of civilization, where shall we look for the much-talked-of "dawnings of history"

By this new standard, the Romans seem our contemporaries in latter-day civilization; the "Golden Age" of Greece is but of yesterday. The pyramid-builders are only relatively remote. The men who built the temple of Bel at Nippur, in the year (say) 5000 B. C., must have felt themselves at a pinnacle of civilization and culture.

As Professor Mahaffy has suggested, the era of the Pyramids may have been the veritable autumn of civilization. Where, then, must we look for its springtime:

The answer to that question must come, if it come at all, from what we now speak of as prehistoric archeology; the monuments from Memphis and Nippur and Ninevah, covering a mere ten thousand years or so, are records of recent history.

ARCHEOLOGY AND CLASSICAL HISTORY

We have seen that the general trend of Oriental Archeology has been reconstructive rather than iconoclastic. Equally true is this of recent classical archeology. Here no such revolution has been

effected as that which virtually created anew the history of oriental antiquity; yet the bearings of the new knowledge are similar in kind if different in degree.

The world had never quite forgotten the history of the primitive Greeks as it had forgotten the Mesopotamians, the Himyaritic nations, and the Hittites; but it remembered their deeds only in the form of poetical myths and traditions.

These traditions, finding their clearest delineation in the lines of Homer, had been subjected to the analysis of the critical historians of the early decades of the 19th century, and their authenticity had come to be more than doubted.

The philological analysis of Wolf and his successors had raised doubts as to the very existence of Homer, and at one time the main current of scholarly opinion had set strongly in the direction of the belief that the "Iliad" and the "Odyssey" were in reality but latter-day collections of divers recitals that had been handed down by word of mouth from one generation to another of bards through ages of illiteracy. It was strenuously contended that the case could not well be otherwise, inasmuch as the art of writing must have been quite unknown in Greece until after the alleged age of the traditional Homer, whose date had been variously estimated at from 1000 to 800 B. C. by less skeptical generations.

It had come to be a current belief that the Iliad was first committed to writing in the age of Pisistratus. A prominent controversialist, Mr. Paley, even went so far as to doubt whether a single written copy of the Iliad existed in Greece at the time of the Poloponnesian War.

The doubts thus cast upon the age when the Homeric poems first assumed the fixed form of writing were closely associated with the universal skepticism as to the historical accuracy of any traditions whatever regarding the early history of Greece. Cautious historians had come to regard the so-called "Heroic Age" as a pre-historic period regarding which nothing definite was known, or in all probability could be known.

It was ably argued by Sir George Cornewall Lewis, in connection with his inquiries into early Roman history, that a verbal tradition is not transmitted from one generation to another in anything like an authentic form for a longer period than about a century. If, then, the art of writing was unknown in Greece before, let us say, the 6th century B. C., it would be useless to expect that any events of Grecian history prior to about the 7th century B. C. could have been transmitted to posterity with any degree of historical accuracy.

Notwithstanding the allurements of the subject, such conservative historians as Grote were disposed to regard the problems of early Grecian history as inscrutable, and to content themselves with the recital of traditions without attempting to esablish their relationship with actual facts. It remained for the more robust faith of a Schliemann to show that such skepticism was all too faint-hearted, by proving that at such sites as Tiryns, Mycenæ, and Hissarlik evidences of a very early period of Greek civilization awaited the spade of the excavator.

Thanks to the enthusiasm of Schliemann and his successors, we can now substitute for the mythical "Age of Heroes" a historical "Mycenæan Age"

of Greece, and give tangible proof of its relatively high stage of civilization. Schliemann may or may not have been correct in identifying one of the seven cities that he unearthed at Hissarlik as the fabled Troy itself, but at least his efforts sufficed to give verisimilitude to the Homeric story. With the lessons of recent Oriental archeology in mind, few will be skeptical enough to doubt that some such contest as that described in the Iliad actually occurred.

And now, thanks to the efforts of a large company of workers, notably Dr. Arthur Evans and his associates in Cretan exploration, we are coming to speak with some confidence not merely of a Mycenæan but of a pre-Mycenæan Age.

As yet we see these periods somewhat darkly. The illuminative witness of written records is in the main denied us here. Some most archaic inscriptions have indeed been found by the explorers in Crete, but these for the present serve scarcely any other purpose than to prove the antiquity of the art of writing among a people who were closely in touch with the inhabitants of Hellas proper.

Most unfortunately for posterity, the Greeks wrote mainly on perishable materials, and hence the chief records even of their later civilization have vanished. The only fragments of Greek manuscripts antedating the Christian era that have been preserved to us have been found in Egypt, where a hospitable climate granted them a term of existence not to be hoped for elsewhere. No fragment of these papyri, indeed, carries us further back than the age of the Ptolemies; but the Greek inscriptions on the statues of Rameses II.

at Abu-Simbel, in Nubia, give conclusive proof that the art of writing was widely disseminated among the Greeks at least three centuries before the age of Alexander.

This carries us back towards the traditional age of Homer.

The Cretan inscriptions belong to a far older epoch, and are written in two non-Grecian scripts of undetermined affinities. Here, then, is direct evidence that the Ægean peoples of the Mycenæan Age knew how to write, and it is no longer necessary to assume that the verses of the Iliad were dependent on mere verbal transmission for any such period as has been supposed.

But even were direct evidence of the knowledge of the art of writing in Greece of the early day altogether lacking, none but the hardiest skeptic could doubt, in the light of recent archeological discoveries elsewhere, that the inhabitants of ancient Hellas of the "Homeric Age" must have shared with their contemporaries the capacity to record their thoughts in written words.

We have seen that Oriental archeology has in recent generations revolutionized our conceptions of the antiquity of civilization. We have seen that written documents have been preserved in Mesopotamia to which such a date as 4500 B. C. may be ascribed with a good deal of confidence; and that from the third millenium B. C. a flood of contemporary literary records comes to us both from Egypt and Mesopotamia. Aforetime it had been supposed that Hellas was entirely shut out from this Oriental culture. Historians have found it hard to dispel the idea that civilization in Greece was a very late development, and that the culture

of the age of Solon sprang, in fact, suddenly into existence, as it seems to do in the records of the historian.

But the excavations that have given us a knowledge of the Mycenæan Age have proved conclusively, not alone that civilization existed in Greece in an early day, but that this civilization was closely linked with the civilization of Egypt. Not only have antiquities been found in Crete that point to Egyptian inspiration, but more recently Professor Petrie found at Tel el-Amarna Mycenæan pottery. The latter find has a peculiar significance, since the date of the Tel-el-Amarna collection is definitely fixed between the years 1400 and 1370 B. C.

ANTIQUITY OF GREEK CULTURE

It is demonstrated, then, that as early as the beginning of the 14th century B. C. the Mycenæan civilization was in touch with the ancient civilization of Egypt.

One must not infer from this, however, that the two civilizations met on anything like an equality. Indeed, in the wonderful Tel el-Amarna collection there is a suggestive absence of literary documents from the Ægean that demands a word of notice. The Tel el-Amarna collection, it will be recalled, consists of the royal archives of King Amenophis IV. of the XVIIIth Egyptian dynasty, who in the latter years of his reign chose to be known as Khu-u-Aten, "the glory of the solar disc." His son-in-law was Tut-Ankh-Amen, of current popular interest.

This monarch, Amenophis IV., had retired from Thebas and established his court on the site

now known as Tel-el-Amarna, where he founded the city which existed only during the brief period of thirty years ending with the death of the monarch about 1370 B. C. The date of the documents found in the royal library is, therefore, fixed within very narrow limits.

The documents in question consist chiefly of letters, and constitute one of the most important archeological finds. These letters came to the king from almost every part of Western Asia, including Palestine and Phenicia, Babylonia, and Asia Minor. Strangely enough, all the letters are written in the Babylonian character, and most of them are in the Babylonian language. They afford, therefore, most striking evidence of a widespread diffusion of Babylonian culture.

Incidentally they prove, to the utter confusion of a certain school of Bible critics, that the art of writing was familiarly known in Canaan, and that Egypt and Western Asia were in full literary connection with one another, long before the time of the Exodus. Hence all the elaborate arguments based on the supposition that Moses probably could not write fall to the ground.

On the other hand, the absence of letters from Mycenæ among the tablets of Tel el-Amarna must be regarded as at least suggestive. Seemingly the widespread Babylonian culture had not reached the Ægean peoples; yet these peoples can not have been wholly ignorant of things with which commercial intercourse brought them in contact.

The point is of no very great significance, however, since no one has pretended that the Western civilization compared with the Eastern in point of antiquity; and in any event, no amount of nega-

tive evidence weighs a grain in the balance against the positive evidence of the Cretan inscriptions.

In short, then, the researches of the archeologist are tending to reconstruct the primitive classical history; and here, as in the Orient, it is evident that historians of the earlier day were constantly blinded by a misconception as to the antiquity of civilization. Such a fruitage as that of Greek culture of the age of Pericles does not come to maturity without a long period of preparation. Here, as elsewhere, the laws of evolution hold, permitting no sudden stupendous leaps. But it required the arduous labors of the archeologist to prove a proposition that, once proven, seems self-evident.

ARCHEOLOGY AND THE EVOLUTION OF ART

What is true of Greek civilization in general is specifically true of the flower of that civilization, Greek art.

Whoever would see the story of the evolution of Greek art illustrated, should go to the British Museum in London and pass from the Egyptian hall, with its grotesque colossi, to the Assyrian rooms, with their marvellous bas-reliefs, and then on to the Elgin marbles from the Parthenon. In particular, the art treasures of the Assyrian collection should demand the closest scrutiny. In the Ninevah gallery, for example, where one finds collections of strange Assyrian books, the walls are flanked everywhere with bas-reliefs that come from the same burial place that once stored the literary treasures.

It appears that the kings of that far-off time and land were connoisseurs of arts as well as

patrons of literature; and the art treasures of their palaces certainly form the most striking, if not the most important, part of the mementos they have left to us. The more closely these figures in low relief are examined, the more wonderful they will seem. They take the place of the Egyptian carvings in the round; and if they are less striking to first view than the great sarcophagi, the grotesque gods, and colossal animal forms of that people, they will prove infinitely more expressive and incomparably more artistic on closer inspection.

For these flat sculptures depict, not alone gods and sacerdotal scenes, but everyday affairs and the events of Assyrian history. The bas-relief was clearly the focal point of Assyrian art. Even the great bulls and lions that guarded the palace entrances were only partially detached from their background, and a frescoed statue of King Assurnazir-pal shows the same tendency.

The full-rounded statue was not indeed unknown to them, as several examples testify; but their real forte lay in mural decorations in low relief. And the particular walls on which the artists mainly expended their skill, if we may judge from what the ruins have revealed to us, were not the walls of temples but the palaces of kings.

It is quite clear that these great conquerors of antiquity were very human, very like their successors of after times. They loved to have their heroic deeds, real or alleged, heralded to the world, and recalled incessantly to their own memories. So one finds whole histories epitomized on these walls,—wars, conquests, victories; the storming

of cities, the slaughter of the enemy, the leading of captives, and bringing of tribute by subject people,—everything, in short, but Assyrian reverses; the court artist, true to his colors then as now, never made the mistake of depicting those

As historical records these sculptures are of priceless value, both for what they tell of political history and for the light they throw on the powers and limitations of antique art.

But before you venture to judge the Assyrian artist in the latter regard, you must pass on to the room of Assur-nazir-pal, and from that to the adjacent room, where the mural decoratons of the dining-hall of the last of the great Assyrian kings, Assur-bani-pal, have been placed in situ, reproducing an effect which they first made in the palaces of Ninevah in the 7th century B. C. Here you may see at once both another phase of royal life in Assyria and another stage of Assyrian art.

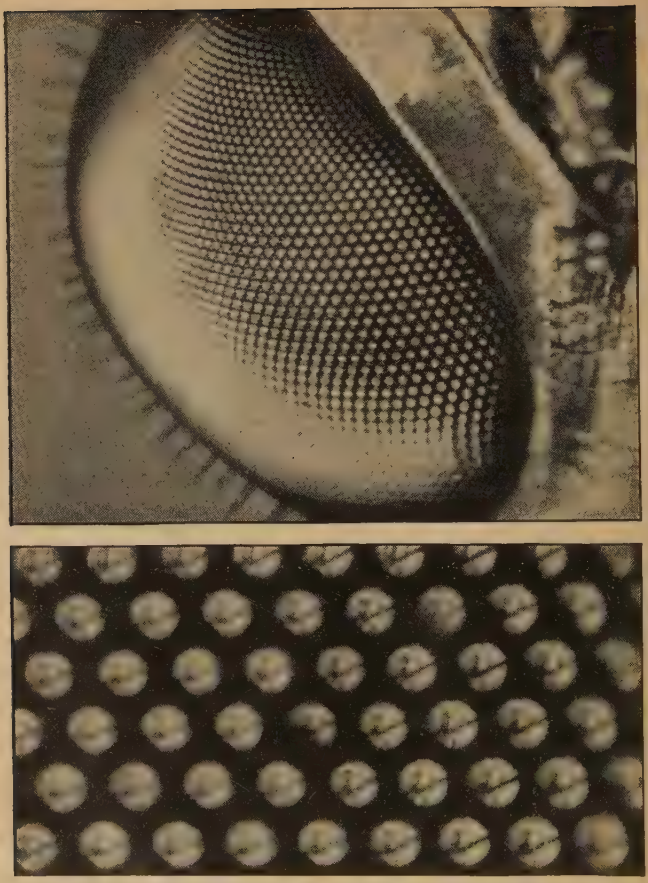
Not war, but the chase, is now the theme. King Assur-bani-pal is seen in pursuit of the goat, the wild ass, the lion. The king, of course, towers above his attendants, tho not in the grotesque disproportion of the Egyptian paintings. To the Oriental mind, such excessive stature seemed indissoluble from royal station. One recalls how the mother of Darius, made captive at Issus, mistook Hephæstion for the king, because he was taller than Alexander; and how Agesilaus, when he went to Egypt as an ally of the Egyptians, was held in contempt, despite his renown, because of his diminutive stature; and one can not help wondering what would have been the real aspect of the Assyrian and Egyptian monarch could they have been subjected to the camera.

Be that as it may, there was apparently no doubt in the mind of the court artist as to what his chisel should reveal in this respect, and the king may always be distinguished by his stature, without regard to his royal robes. Still, it is notable, as a distinction between Egyptian and Assyrian art, that the realistic eye of the Assyrian sculptor never let him depict the king as a Brobdignag among the pigmies, after the Egyptian fashion. At the most he is a head taller than those about him.

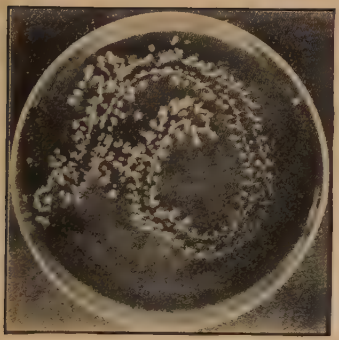
The royal hunter pursues his quarry sometimes on foot, more usually standing in his chariot. His weapon is usually the bow, sometimes the spear; on one occasion he grapples with the lion, hand to jowl, and stabs the quarry to the heart with a short sword. The quiet dignity and royal calm with which the feat is achieved must have insured the artist a high and enduring place in the royal favor.

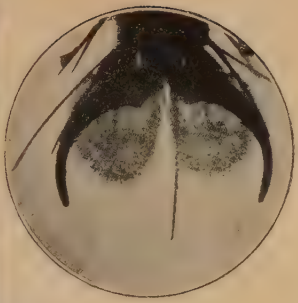
The action, however, of the human figures in these sculptures is always sedate and reposeful, suggestive of reserved strength perhaps, or possibly of the artist's limitations. Whichever it is, the real power of the artist is not known in the human figures. These, to be sure, are in part strongly anatomized; in the main, they are fairly proportioned, and, unlike the Egyptian figures, they have the shoulders drawn in proper perspective. But the faces are fixed, impassive; the eyes are not in perspective, and, as a whole, they can not claim high merit as works of art, viewed from an abstract modern standpoint. Considered in relation to their time, they are wonderful enough, so far ahead are they of anything that

SHIELDING THE VACCINATED ARM FROM INFECTION

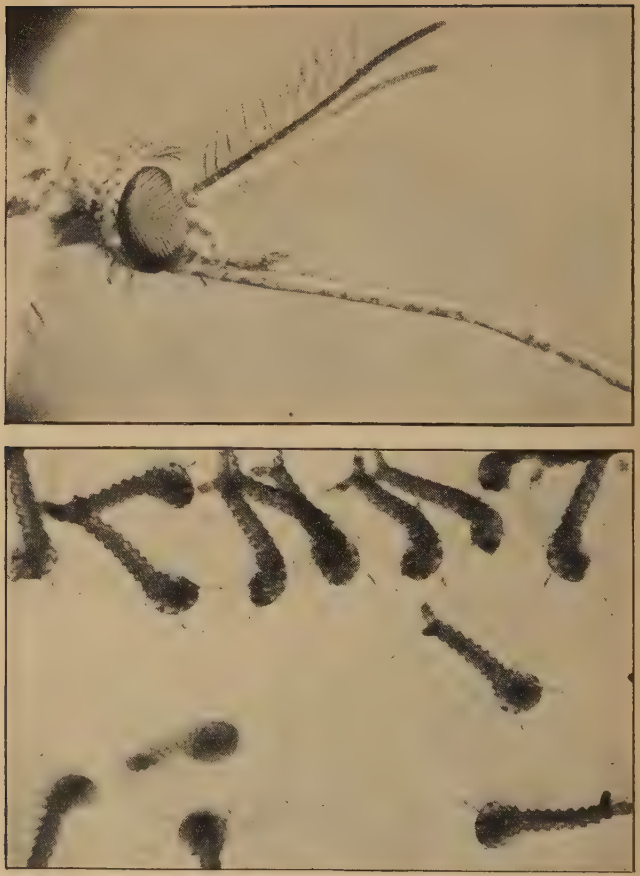


EYE OF THE "TYPHOID FLY" WITH MYRIADS OF LENSES, AND (BELOW) ENLARGED VIEW OF A GROUP OF THE LENSES EACH SHOWING THE IMAGE OF A PAIR OF SCISSORS. (COURTESY OF THE PICTORIAL CLUBS OF AMERICA, NEW YORK)





HOW THE "TYPHOID FLY" DISSEMINATES DISEASE GERMS: REGURGITATING LIQUID TO DISSOLVE FROSTING ON CAKE (BELOW), AND ENLARGED VIEW OF GERM-CARRYING FOOT AND CONTAMINATED CULTURE-MEDIUM SHOWING WHERE A FLY HAS WALKED.
(COURTESY OF THE PICTORIAL CLUBS OF AMERICA)



THE GERM-CARRYING MOSQUITO: THE LARVAL OR "WIGGLER" STAGE, SOME OF THE INDIVIDUAL BREATHING THROUGH THEIR "TAILS" AT THE SURFACE OF THE WATER, AND HEAD OF ADULT FEMALE SHOWING ANTENNAE AND SKIN-PUNCTURING PROBOSCIS. (COURTESY OF THE PICTORIAL CLUBS OF AMERICA)

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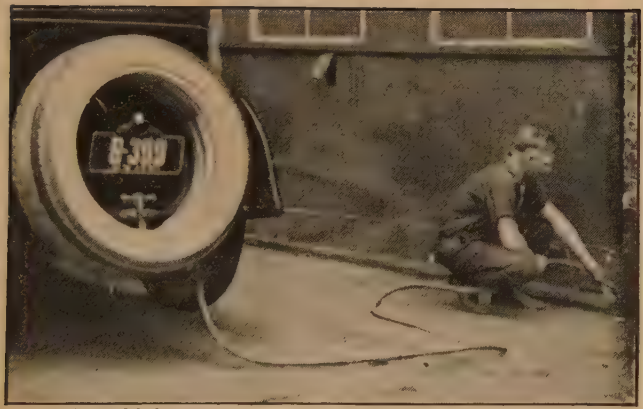
THE TSETSE FLY, CARRIER OF SLEEPING SICKNESS (ABOVE AT LEFT) AND AN ALLIED SPECIES, AND A THERAPEUTIC INOCULATION

THE RAT-FLEA THAT CARRIES GERMS OF THE PLAGUE (INSET), AND THE REMOVAL OF DEAD FLEAS FOR EXAMINATION FROM A CHLOROFORMED RAT



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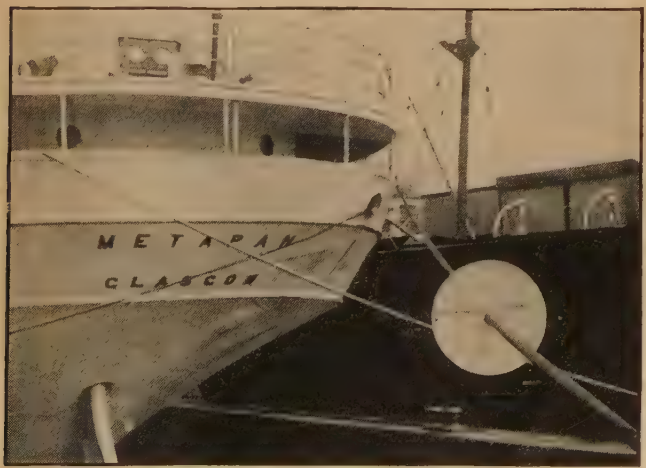
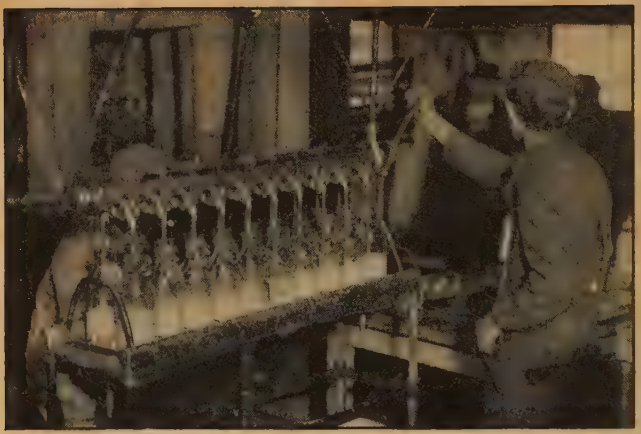


EXTERMINATING THE PEST-DISSEMINATING RAT WITH FUMES FROM AN AUTOMOBILE, AND GUARDING A SHIP AGAINST INVASION OF RATS BY PLACING SHIELDS ON THE HAWSERS



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PREVENTING THE SPREAD OF DISEASE GERMS BY THE PASTEURIZATION OF MILK: FILLING BOTTLES ASEPTICALLY WITH PASTEURIZED MILK (ABOVE) AND CREAM

we could suppose to have been accomplished in the world of that day. But they fall far short of the standard which the same artist has himself given us in animal figures of his composition.

It seems as if the human figures might have been done from memory, whereas the animal forms are clearly enough from the natural model.

Indeed, when we turn to these animal figures we may criticize them, not with reservation as to their age, but from the standpoint of modern art, and as individual figures they will not be found wanting. The three fundamental canons—"proportion, action, aspect"—have been successfully met. The lions skulk sullenly from their cages, spring furiously into action, or roll in death-agony at the will of the depicter. One lioness, with spine broken by an arrow, dragging her palsied hind-quarters, is a veritable masterpiece. The same is true of many of the figures of goats, of running and pacing wild asses, and of dogs.

As a whole, these animal frescoes are nothing less than wonderful. It is worth a visit to London from the remotest land to see these sculptures from the palace of the old Assyrian king.

Still, tho these bas-reliefs have intrinsic merits as works of art, their chief value is for what they teach regarding the evolution of art in the world. Previous to their discovery it had been supposed that the stiff formalism of Egyptian sculpture represented the fullest flight of pre-Grecian art; and that Greek art itself had stepped suddenly forth, rather a new creation than an evolution. But the pick and shovel of Layard at Ninevah dispelled that illusion. For these art treasures, that had lain there under the deposits of centuries,

were found to represent an enormous advance upon Egyptian models, precisely in the direction of that realism for which Greek art is distinguished.

If we would judge how direct and unequivocal was the impulse which the dying nation transferred to the adolescent one in point of art, we have but to take a few steps in the British Museum, from the Assyrian rooms to the wonderful hall that holds Lord Elgin's trophies from the desecrated Parthenon. Look then upon the frieze of bas-reliefs that bear the magic name of Phidias. If anything can reconcile us to the act that deprived Greece of her priceless heirlooms, it is the fact that they have found lodgment here close beside their Oriental prototypes, where half a million visitors each year may at least have an apportunity to learn the lesson that human progress is an accretion, a growth, a building upon foundations; and specifically, that Greek art, no less than other forms of human culture, was an evolution, and not an isolated miracle.

For what is the Parthenon frieze, as we now come to it fresh from the palaces of Ninevah, but an Assyrian fresco adapted to the needs and ideals of another race and developed by the genius of a newer civilization?

The profiled figures in low relief coursing together, are they different in conception from the profiled figures of the palaces we have just left? The horses of the Parthenon frieze might almost seem to have stepped bodily from the palaces of Assur-bani-pal. They have gained something in suppleness of limb, have altered their attitude in a measure, to be sure, thanks to their now environ-

ment. But their type has not changed by so much as an actual breed of horses might be changed in as many generations.

Note the head, the most typical and characteristic feature of this Grecian steed. Line for line it is the same head, trappings aside, that we have just seen at Nineveh.

Even the defects of the Assyrian drawing are there—the too small and slender face, and receding lower jaw, the tiny ear, the far too full and "chuffy" neck.

Possibly no horse in nature was ever like this, but the Assyrian artist so conceives it; the Greek copies that conception; and the distorted type will be transmitted down the generations to the Italian of the Renaissance, to the classical painters of Spain, the Netherlands, and Germany, and France; nay, even to the artist of the 19th century. The court artist of an Oriental prince of the 9th or 10th century B. C. conceives a certain ideal; and, following him, a certain type of sculptured horse, such as the artist who carved it had never seen, steps before the chariots of Napoleon's Arc de Triomphe, in 19th-century Paris.

Ah, if only that nameless creative dreamer of far-off Assyria could been known!

ARCHEOLOGY AND PRE-HISTORY

The students of oriental archeology have thus revealed to us in gratifying detail entire chapters of the history of times that for our immediate forebears were envisaged only as vaguely outlined penumbral epochs at the very dawning of civilization. But in the meantime, the even newer science of prehistoric archeology has given us

glimpses into epochs so much more remote as to make the Egyptians of the earliest dynasties and the precursors of the Babylonians—not to mention the Greeks—seem by comparison our veritable contemporaries.

Accurate chronologies are not here in question; but the student of early man, at once archeologist and paleontologist, computes time in terms of glacial and interglacial epochs. In his terminology, "recent" means, let us say, within the past twenty-five thousand years; and "remote" implies periods a hundred thousand, or for that matter five hundred thousand, years farther removed.

If the alleged finding of a fossil human skull in the Tertiary strata of Patagonia (reported in March, 1923) should be authenticated, the chronology of the "Age of Man" must be again extended by perhaps a half million or even million years. Even Pithecanthropus, the "Ape-man" of Java, of whom we have learned in an earlier volume, may come to be regarded as a parvenu.

The story of the finding of various relics of prehistoric man in Europe in the nineteenth century was told in the first volume of the present series. We are here concerned with certain newer developments, none of them revolutionary in character, but rather supplementary of the earlier revelations.

Interest centers largely upon a dozen or so relics, ranging from fragments of skulls to complete skeletons, that have come to light in the course of the present century, mostly in western Europe (the exception being, a skull found in South Africa in 1919 and the Patagonian find of 1923 above referred to). Of even greater

interest than the human relics themselves, perhaps, are the implements and the cave-wall drawings and sculptures that give glimpses of the development of industries and nascent culture of the remote Neolithic (Smooth-stone) time and the yet remoter Paleolithic (Rough-stone).

Anthropologists speak of the various relics as representing different races of men. They even claim for the individual represented by portions of a skull and jaw found at Piltdown, Sussex, England, generic divergence, christening him *Eoanthropus,* the "Dawn Man." In this case, however, there is some question as to whether the two fragments (found in 1911) belong to the same individual, and the non-committal name "Piltdown Man" is more generally adopted in referring to these type-specimens.

So many relics similar to the type Neanderthal have been found, notably in Austria and in France, that we hear of subdivisions within this race, a "Krapina" type and a "Mousterian" type, giving opportunity for comparative study.

Older than Neanderthal man is the man of Heidelberg, named, as is customary, after the place of discovery; the type relic in this case being a lower jaw with teeth. The man of Heidelberg, according to the chronological scheme prepared by Dr. C. A. Reeds in cooperation with Professor Henry Fairfield Osborn, occupies a position between old *Pithecanthropus* and the man of Piltdown. The latter was succeeded by the race of Neanderthal; following which came the man of Grimaldi, known only by two skeletons found in a grotto near Mentone in 1901.

Then, in the newest time, following the fourth

glacial epoch, perhaps only twenty-five thousand years or so ago, came the wonderful Crô-Magnon race, typed by three skeletons and fragments of two others found as long ago as 1868 at Crô-Magnon, Dordogne; and further represented by two skeletons, male and female, revealed at Obercassel, near Bonn, Germany, in 1914.

It is the last-named race in particular that left in the caves of France and Spain artistic souvenirs in the form of mural paintings and sculptures that have excited the wonder and admiration of our own generation.

A PREHISTORIC MASTERPIECE

In his notable book *Men of the Stone Age,* Professor Henry Fairfield Osborn, of the American Museum of Natural History, gives an account of the finding by the French archeologist, the Comte de Begouen, at the Cavern of Tus d'Audoubert, of a piece of sculpture which apparently represents the masterpiece of masterpieces of the preserved (or at least of the hitherto discovered) works of artists of the old stone age.

These sculptures, modeled in clay, represent two bison, male and female, each about two feet in length, done in high relief, against the wall of a remote chamber of a cavern that for thousands of years after prehistoric animals and men deserted it was unvisited. They are in a state of almost perfect preservation. They represent the animal forms with a fidelity to life that only an accomplished artist of our own day could duplicate.

Other chambers of the same cave are reported to show low-engraving relief, fine in execution,

of the bison, the favorite subject as in all other caverns; of horses, of the head of a stag with its horns still in the velvet, and of a mammoth. The ground of similar chambers was covered with imprints of the claws of the bear, skeletons of which were found here and there. All the canine teeth of the skulls had been extracted to make ornaments. Outlines of human feet are to be seen in the humid and soft clay,—footprints that were made at a time antedating the building of the pyramids by some tens of thousands of years. All of which is in the highest degree thought-provocative.

THE "APE-MAN" IN A NEW HABITAT

Peculiar interest attaches to the fact that a fossilized skull of a man said to be of very primitive type has recently been found in Rhodesia. The skull, which is said to be complete save for the lower jaw, is reported to bear a close resemblance to the famous skull discovered in Java in 1891, which Haeckel characterized as representing a type intermediate between the ape and man and which therefore he named *Pithecanthropus erectus*.

The Rhodesian skull was found in the "Bone Cave" of the Broken Hill mine, hitherto famous for stalactites and stalagmites which were not only beautiful but of commercial value because of their content of phosphates of zinc and lead. Fossil remains of elephants, lions, leopards, and other African animals had been discovered in great quantity, but no trace of man until the present skull was found at a depth, it is said, of sixty feet below water level.

When the skull of the original "Ape-man" was discovered, in 1891, the controversy over the question of man's origin was still sufficiently acute in the memory of the generation to lend popular interest to this new bit of tangible evidence. Thirty years have effected a vast change in this regard. There are no longer any significant opponents of the general thesis of evolution; and to speak of man's anthropoid ancestors no longer excites a controversial spirit.

So the chief interest of the Rhodesian find for anyone except the technical anthropologist lies in the geographical site rather than in the ethnological characteristics of the discovery. It tends to corroborate the moot belief that early man inhabited Africa. This observation links with Dr. Nuttall's observation that the blood of existing African monkeys is more closely related to that of man (as proved by precipitin tests) than is the blood of South American monkeys. The discovery brings us one step nearer to the localization of the scientific equivalent of the Garden of Eden.

The popular attitude toward problems of evolution has changed very markedly since 1891, when the remains of the original "ape-man" were discovered. There is no longer any controversy worth mentioning about the "missing link." But interest in the records of our pre-human ancestors has naturally increased in a generation that accepts the evolutionary hypothesis without challenge.

The fossil beds of Europe, as we have seen, have yielded remains of a so-called Heidelberg man of about two hundred and fifty thousand

years ago, with skull much larger than that of the ape-man, but primitive in comparison with the skull of the so-called Crô-Magnon man who inhabited Europe at a period far more recent, yet still prehistoric. But, altho these remains of men of the rough-stone ages have been found in Europe, it is believed by most anthropologists that the cradle of the human race must be sought in Asia. There is apparently a gap of a quarter of a millon years between the ape-man of Java and the oldest known prehistoric man of Europe,—perhaps one hundred thousand generations. Must not the successive populations of this vast company have left some fossil remains?

That is one at least of the questions that the representatives of the American Museum of Natural History hope to answer in the course of the explorations that they are undertaking. The project, in which the Museum has the cooperation of the American Asiatic Association and of *Asia* magazine, contemplates the zoological exploration of regions of Central Asia that are almost or quite unknown to the western world.

There are even remnants of nearly thirty living tribes bearing such unfamiliar names as Lolos, Mopas, and Lisos, as to whose origin and racial antecedents nothing is known.

The fossils of the region have been carefully guarded by the Chinese, who ascribe to them medicinal qualities. Then there are many varieties of animals that have hitherto been little sought by zoologist or hunter,—wild horses of the Gobi Desert, and wild camels and asses, and antelopes that can run sixty miles an hour.

On the Tibetan Steppes, we are told, are enor-

mous yak, snow-leopards, giant pandas, and beautiful golden monkeys, some of these specimens being among the rarest and least known animals of the world.

In the forests of Manchuria is the long-haired tiger of the Amur River; a tiger larger and finer than the Royal Bengal of India, which has furnished sport for kings and emperors; a tiger living in caves amid forests drifted deep with snow.

Such are some of the allurements of the region as recorded in a bulletin of the American Museum of Natural History. The expedition plans five years of work, covering everything of interest zoologically, anthopologically, and paleontologically. Specimens of fossil remains and living animals will find their way in due course to the Museum of Natural History and the New York Zoological Gardens, respectively.

But the chief interest centers in the hope that something may be revealed as to man's very remote ancestors—the forerunners, perhaps, of the earliest paleolithic men of Europe.

SPEEDING UP EVOLUTION

One of the great enigmas confronting the student of fossil life is the fact that some forms appear to change with relative rapidity, geologically speaking, whereas others remain static age after age. Students who are metaphysically inclined have been disposed to assume that there must have been some inexplicable force urging the various races this way and that, some to changes that may be interpreted as progressive, others toward degeneration and death.

Such a view, however, is combated by other

investigators, who seek an explanation of all modifications in the response of the organism to environmental influences. The latter view is, of course, essentially the Darwinian conception; but those who hold it have often been puzzled to explain why creatures of the same epoch, subject therefore to the same climatic modifications, vary so widely in their response.

This question among others is dealt with by Dr. F. A. Bather, President of the Geological Section of the British Association for the Advancement of Science, in an address delivered at the Cardiff Meeting of that organization. He pointed out that creatures whose remains may be found side by side were not necessarily subjected to the same conditions.

We must distinguish between the place of birth, of life, of death, and of burial of the different creatures.

There may be land animals, creatures that lived at the surface of the sea, those that inhabited the middle depths, and forms that never left the sea bed itself, all deposited in one stratum. Even sessile forms of life, like the echinoderms, may vary a good deal in habitat, some being attached to sea weeds; others growing on stalks above the bottom; others clinging to shells or stones lying on the top of the sea floor; yet others partly buried beneath its muddy sand, or in grottos beneath it, connected with overlying waters by passages.

These differences of habitat obviously imply diverse environmental influences.

Such diversions are of course far more pronounced when we consider creatures of different species living in the same epoch. Dr. Bather

quotes Professor Aber as having argued that the varying rate of evolution depends solely on the changes in outer conditions, and as having cited by way of illustration the evolution of whales, sirenians (manatees), sea cows, and horses during the so-called Tertiary Epoch, which he correlates with the nature of the food.

He suggests that the manatees underwent a steady, slow change, because, though they migrated from land to sea, they retained their habit of feeding on the soft water plants. The horses, on the other hand, altho they remained on land, evolved somewhat more rapidly than the manatees, because they became eaters of grain, and their habits were modified to adapt them to the life of the plain.

Meantime the whales, migrating into the sea at about the same time with the ancestors of the sea-cow, underwent rapid and extraordinary evolution. Not at the outset, to be sure, while they remained near the coast and kept to the ancestral diet; but after they became flesh eaters and took to hunting fish and then to eating large and small cephalopods. Thanks to this utter change of diet and habit, the evolution of the whales was "almost tempestuous."

But subsequently many whales again changed their dietetic habits, and took to swallowing minute floating organisms. They had apparently exhausted the possibilities of ocean provender, and from that time to this they have changed very slowly.

Dr. Bather urges that the evidence justifies the conclusion that all the evolutionary changes with which the geological record makes us familiar are

the result of reaction to the stimuli of the outer world, and that the rate of evolution depends on these outer changes.

He makes an application of this thesis to the case of man, who has the power of altering his environment and of adapting racial characters through conscious selection; urging that, owing to these unique possibilities, the human race need not necessarily enter on a period of decadence; but that, on the contrary, by deepening our knowledge of ourselves and of our world, and by controlling our energy and guiding our efforts in the light of that knowledge, we may prolong our racial history and hasten our advent to ages and to heights as yet beyond prophetic vision.

CHAPTER V

MIXED RACES IN ANCIENT HISTORY

EVERY fancier of special breeds of horses, dogs, or cats is aware that the finely bred animal, while gaining special qualities in one direction, loses other qualities. Thus, to name but a single instance, the various breeds of toy spaniels and the like, while becoming admirable household pets, lose those instincts and capacities that would enable them to care for themselves if turned out with a set of mongrels.

Moreover, where an attempt is made to carry specialization to its limits through inbreeding, the specialized race suffers loss of stamina. Every breeder of animals has recognized this, time out of mind.

Now precisely the same rules apply to the human species, and a certain recognition of this fact is evident in the laws against marriages of too close consanguinity,—albeit the justification for such laws is usually found in moral rather than in physiological reasoning.

Indeed it is probable that most people never give the physiological aspects of this question a thought. Yet it is a question which, in its broader aspects, concerns not only every individual, but the entire human race. For the most cursory examination of the history of nations makes it obvious that the laws of heredity, as applied to racial mingling, have had in all ages a most important influence on human progress.

Curiously enough most barbarian tribes develop customs that would seem to imply an appreciation of the laws of heredity in question. Take as a typical illustration the marriage customs of such American Indians as the once famous Iroquois or Five Nations. This famous commonwealth—if such we may call it—comprised at an early day five, and later six, so-called nations, doubtless originally offshoots of a single tribe.

The proof of common origin is found in the fact that all the members of the various tribes belonged to one or another of eight so-called clans, each represented by its specific emblem or totem. Thus there was the clan of the wolf, the clan of the tortoise, the clan of the bear, etc. The different totems have different degrees of rank and dignity, and, according to Parkman, those of the bear, the tortoise, and the wolf were among the first in honor. Readers of Cooper's *Last of the Mohicans* will recall the effect produced upon the Delawares when they discovered that their captive Uncas belonged to the clan of the tortoise.

For our present purpose the significance of this system of clanship is this: According to the most firmly established Iroquois customs, which had all the force of laws, no man might marry a woman of his own clan. "Thus," says Parkman, "Wolf can not marry Wolf; but he may, if he chooses, take a wife from the clan of the Hawk or any other clan but his own. It follows that when this proportion is rigidly observed, no single clan can live apart from the rest; but the whole must be mingled together and in every family the husband and wife must be of different clans."

It is obvious that this arrangement sufficed to

keep up a community of interest among the different tribes, insuring for the confederacy a permanency not otherwise possible.

But it is equally obvious that the arrangement sufficed to prevent marriages in close consanguinity, and provided for an intertribal mixture that must have made for racial virility.

We may well doubt whether the Indian himself appreciated this important feature of the arrangement; yet on the other hand it is by no means certain that he did not have an inkling of it, for the custom in question was based on many generations of experience, and it is at least possible that the disastrous effects of inbreeding may have been observed, and the custom of marriage without the clan developed as a remedy. Indeed the almost universal prevalence of the same custom among the higher races of barbarians in different quarters of the globe lends color to this view. Marriage by capture, for example, which is a familiar custom among various savages, obviously effects the same end and may have had the same origin; more probably, however, it arose as a practical result of female infanticide.

But whatever the origin of this and similar customs, the result is of vast importance for the permanency of the race.

If we turn from the barbarian to the various civilized races, we shall find that altered conditions of life no longer permit such crude practices as marriage by capture, while such institutions as clanship persist only in the modified form of the recognition of close consanguinity.

How great is the effect of this modification will be obvious when we reflect that in a civilized

community few individuals recognize more than a score or two at most of relatives falling within the proscribed limits of close consanguinity; whereas in the case of the Iroquois just mentioned, one-eighth of all the members of the widely scattered tribes would fall within the same proscription.

It must follow, then, as a matter of course, that marriages in a civilized community take place between persons more closely related on the average than would be the case among such barbarians as the Iroquois. This would be increasingly true as man graduated from the tribal state and came to live in agricultural and manufacturing communities. In such communities various strata of society are soon recognized, comparable in a way, at first glance, to the clans of the barbarian, but differing diametrically in that a member of any given stratum is generally most particular to marry *within* his own class, any failure to do so being socially frowned upon.

In such communities it becomes not at all unusual—as experience of any New England village, for example, will show—for first cousins to intermarry. Indeed under the static conditions of village life it is not unusual for entire communities to become inter-related so that almost everyone of a certain social standing recognizes all the rest in some degree or other of mutual cousinship.

What happens thus on a small scale in a village community finally comes to apply in modified degree to larger aggregations of people.

If we reflect that every individual has in the natural course of events an array of no fewer than 2,046 ancestors, counting no farther back

than ten generations, and that ten generations compass only about two and a half centuries, it will be obvious how far reaching are the ties of consanguinity in any community. When we further reflect how any given environment tends to put its stamp upon all creatures subjected to it, it will be clear that heredity and environment must join hands in the case of any isolated nation to conserve certain characteristics and thus produce a racial type.

Such a type is characterised not merely by uniform physical features, but by established laws, customs, and methods of thought which, as it were, permeate the atmosphere, and can with the utmost difficulty be altered.

Indeed all experience shows that when such conditions have been developed racial stasis supervenes; hide-bound conservatism becomes the order of the day, and progress is possible only through some impulse from without. In such a case no hope remains for the community or nation in question except through racial mingling.

THE CASE OF THE EGYPTIANS

So much by way of general exposition. Let us now seek a few illustrative cases from history.

First let us glance at one of the oldest civilizations of antiquity, that of the Egyptians. There is, to be sure, a good deal of uncertainty as to the exact origin and early development of this people, and there are long periods of its history when our information regarding the exact sequence of events is but meager. There are, on the other hand, two or three important epochs

which supply us interesting data from the standpoint of our present inquiry.

If we go back to the time of the first historical dynasty, we shall find that no fewer than five types of men are represented on the monuments of the period. This in itself gives suggestive information as to the causes of that sudden development of higher culture which marks the period. Many of the ethnic questions involved are still obscure; it is not even certain as to whence the invaders came who overthrew the pre-historic inhabitants. But we know that these conquerors, who came to be known as the true Egyptians, were in contact with the Libyans and Moors on the west and the Cushites and Ethiopians on the east, to say nothing of those Asiatic neighbors with whom, according to the best modern authorities, the Egyptians were closely related.

That the marvelous development of civilisation, monumental remains of which have come down to us from this earliest period, was the output of a race of mixed ethnic character is sufficiently attested by such facts as these.

Moreover, the fact that many rival kings ruled in different regions of Egypt in the ensuing centuries, gives further proof that the seeming homogeneity of the race, which marks the later culture, was of slow development. No one questions that environment puts its stamp upon a race in course of time, and the sweep of Egyptian history, it must not be forgotten, carries us over periods numbered in thousands of years.

It is not yet possible for the historian—perhaps it never will be possible—to ferret out the details of Egyptian history through all these centuries.

For our present purpose it will suffice to come down the generations and glance for a moment at the record of two glorious periods of later history, namely, the 18th and 19th dynasties.

For some centuries prior to the 18th dynasty Egyptian affairs were at a low ebb. The country had been invaded by an alien people, coming presumably from Asia, whose precise origin is uncertain. This people is known to the modern historian as the Hyksos. They appear to have gained supreme power in Egypt, and for several generations Hyksos kings occupied the throne. Obviously the Hyksos must have come in considerable numbers to have gained absolute authority over a people so jealous of their racial superiority as the Egyptians; and we can not doubt that the residence of these strangers in the land for several generations must have led to a considerable racial mingling.

It is a plausible hypotheses, therefore, that this infusion of new blood was at least in part responsible for the new spirit of enterprise that came to invade Egypt with the 18th dynasty.

At all events, King Aahmes, who rose up and banished the usurpers, and his immediate descendants Tehutimes I, Amenhotep I, and Tehutimes II and III, seem a quite different order of beings from the placid Egyptian kings that occupied the throne prior to the coming of the Hyksos. These new rulers, not content with the banishment of the Hyksos usurpers, invaded Asia and carried their conquests as far as the banks of the Tigris.

Tehutimes III in particular, passed into tradition—which as the symbol of genuine truth is sometimes more accurate than history itself—as a

hero to be named beside the never-to-be-forgotten Khufu of the pyramid dynasty.

But after the time of Tehutimes III racial stasis again became evident, and the 18th dynasty finally came to a close in a period of religious fanaticism, in which the power of the king had sunk to a low ebb.

Now again there was need of new blood, and again it would seem that there was an invasion from the east, for this is the period which the Hebrew traditions have made familiar as the time of the Egyptian captivity. Egyptian monuments are strangely silent regarding this event, but we can hardly suppose that the Hebrew tradition would have arisen without some foundation, and we know that just at this time the Kheat, whom the modern historian identifies with the Hittites, had assumed a menacing attitude toward Egypt and were making their influence felt there.

Presently a man appears who achieves fame as a general, and ascends the Egyptian throne as the founder of the 19th dynasty. He is the great Ramses I. His son Seti I is a great conqueror, and his son in turn became famous for all time as Ramses II, known to the Hebrews as the Pharaoh of the Oppression, and to the Egyptians of succeeding generations as a veritable hero of romance.

But now the same old story is repeated. Three generations of virile activity have brought this family also to its climax of power, and the successors of the great Ramses, unable to hold the lands he has conquered, bring this dynasty, like so many preceding ones, to an inglorious close.

It may be added that the rapid decline which

marks family after family of Egyptian rulers was no doubt accelerated by the national custom which made it obligatory for the king to marry his own sister. A counter influence was found, however, in the custom of polygamy which enabled the kings of some period to claim the daughters even of distant Asiatic princes for the royal harem. The custom, however, was comparatively exceptional and practiced only during those relatively brief and isolated periods when a succession of powerful conquerors occupied the throne.

THE BABYLONIANS AND ASSYRIANS

The one civilisation of remote antiquity that rivalled the Egyptian was that of Babylonia-Assyria. It is a moot-point which civilisation is the older, but the records of each cover a period of some thousands of years.

From a period at least as remote as 5000 B. C. to the time of the overthrow of Babylonia by Alexander the Great, there was no interval in which the civilisation of the valley of the Tigris and Euphrates was not important, and throughout much of this time it was rivalled only by Egypt; there were even brief periods when it was absolutely dominant.

Nothing could well be more diverse geographically than the situation of old Babylonia as contrasted with Egypt. The valley of the Nile occupies, as it were, a cul-de-sac, and once the relatively unimportant nations of the south were subordinated it was comparatively easy to shut out contact with the rest of the world. Hence, those long epochs of stasis, during which Egypt developed her peculiar civilisation. Babylonia, on

the other hand, was so situated as to become the natural battle ground of nations.

It is probable that the earliest peoples of whom we have clear historical knowledge emigrated to this region from Central Arabia. Once they had developed the rich agricultural possibilities of the region, they were obliged perpetually to defend their title to it against the encroachments of surrounding nations. There was a long epoch, for example, in the third millenium B. C. when the Elamites were dominant, and a succession of their kings occupied the throne.

The famous Babylonian king, Khammurabi, who lived about 2200 B. C., and whose code of laws, recently discovered, has excited so much interest and comment, banished the last of the Elamite usurpers when he himself seized the throne.

But Khammurabi's successors were in turn overthrown by the invasion of the semi-barbarous Kassites, who apparently came in large numbers and became amalgamated with the Semitic population. The effect of this amalgamation was in modified degree like that which mediaeval Europe suffered when the highly civilised Mediterranean races were subordinated by the barbarian races of northern Europe. In the course of centuries, however, the Kassites became sufficiently civilised to carry forward a progressive work. Indeed, as Goodspeed has suggested, they added perhaps a not unneedful racial ingredient to the "already very complex strains which made up the Babylonian people—an ingredient not without value in infusing fresh and vigorous elements into the doubtless somewhat enfeebled stock."

But in the course of five or six centuries the Kassites themselves became enfeebled, and they were overthrown and a new dynasty established by Nebuchadrezzar I, whose name stamps him as of that Semitic stock to which historians ascribe rightful ownership of the soil.

The next reverses were due to the growing power of Assyria at the north, the cities of which were originally barbarian colonies. The warlike kings of Accad, who made their final capital at Ninevah, sallied forth in all directions on an almost unending series of warfares, which made them in the time of Sargon and his son Sennacherib (722–681 B. C.), the terror of all western Asia.

But a century later the Assyrian monarchs were so enfeebled that their final and cataclysmic destruction took place at the hands of the Medes and the Babylonians.

No doubt many factors led to the weakness which finally proved ruinous to Assyria. For our present purpose we need name but one: "The early unity of national life," says Goodspeed, "led to pride of race and blood which permitted no admixture, and, as revealed on the Assyrian monumental portraits, resulted in far purer Semitism than was the case with the Babylonians. But purity of blood in course of time enfeebles a people. The Assyrian was no exception."

Meantime, the Babylonian, rehabilitated by fresh admixture with Elamite and Kaldean elements, gave a marvelous exhibition of the power of rejuvenation that lies in an old nation to which new germs of vitality are added, by producing the

new dynasty of rulers that culminated in the famous Nebuchadrezzar II (604–562 B. C.). This was the last epoch of native glory, however, for presently the Persians under Cyrus conquered the famous old city, and remained virtually its masters until the coming of Alexander the Great.

It should be added, in further explanation of the amazing vitality of this Babylonian stock, that in addition to the constant warlike communication with surrounding nations, there were the scarcely less potent influences of the most important commercial life of antiquity. Indeed the two elements can scarcely be separated. Wherever a Babylonian conqueror went he exacted tribute, and the products of countries as widely separated as Egypt and India—perhaps even of China—found their way to the Babylonian capital.

Moreover, the Semitic conqueror did not content himself with the mere exaction of tribute. It was his custom to depopulate old cities, transferring to Babylonia such of their inhabitants as he did not massacre, and supplying their places with garrisons of his own people.

The familiar accounts of the Babylonian captivity of the Hebrews is but one of multitudinous instances of this custom.

In general, such deported peoples, of widely different nationalities, must have become largely amalgamated with their conquerors. Certain it is that without that racial mingling of which this must have been one sure and almost perennial source, the long continued prosperity of Babylonian civilisation would be historically inexplicable.

PERSIAN AND GREEK

Mention has just been made of the overthrow of Babylonia by Persia under Cyrus, and the subsequent subjugation of the Persian civilisation in turn by Alexander the Great.

In keeping with our present purpose, however, it should be noted that while Cyrus is usually spoken of as a Persian, he was more probably an Elamite, and that the nation over which he ruled was at this period, a most conglomerate one, made up of such diverse ethnic elements as Elamite, Median, Scythian, Mandaeitic, and Persian proper.

Somewhat less diverse perhaps, but by no means homogeneous, were the racial factors that went to form the heritage of the Macedonian, Alexander, who loved to call himself a Greek, but to whom the Greeks proper denied the appelation.

But who, it may be asked, were the Greeks themselves who thus denied kinship with the great Macedonian?

Let us admit at once that no really satisfactory answer can be given to this question. The remote origins of the Greeks are as obscure as all other racial sources. The Greeks themselves had only vague traditions on the subject to take the place of history, and modern scholarship has at best sufficed to supply new guesses, rather than definitive answers.

The great difficulty, here as elsewhere in ancient history, is found in the fact that the ancient writers themselves had a defective historical sense, and the haziest of notions regarding questions of ethnology. Add to this the fact that no records were available with which to gain enlightenment regarding remote periods, and it is

little wonder that much confusion prevails regarding the actual ethnic relations of the Greeks.

The recent investigations of the archaeologists, however, have thrown a flood of light on the subject of early Greek history, and at least serve to give new points of view for the interpretation of the old traditions. And what from the present standpoint is most significant, all the investigations tend to make it more clear that the ancient Hellenic population was one of variously mixed racial antecedents. "We are gradually learning," says Hogarth, "that the classical Hellenes were of no pure race, but the result of a blend of several racial stocks into which those pre-existing in his land can hardly fail to have entered."

The racial stocks here referred to as pre-existing in the land, are the early peoples whom the Greeks themselves of the later day knew as Pelasgi, Minyae, Leleges, Danai, Carians, and various others. All these, it is held, must have shared in that early civilisation which the modern archaeologist speaks of as Mycenaean.

This civilisation was at its height probably from about 1600 to 1200 B. C. At this time such cities as Mycenae and Tyrens were powerful, and the Greek influence extended to the islands of the Aegean, and even to the continents of Asia and Africa. The excavations of Schliemann and his successors, revealing the great walls and fortifications and the golden relics of material prosperity, have given us a fairly clear picture of the civilisation of this time.

The human skulls that have been preserved prove, according to the ethnologists, that a mixed

race, not exclusively of Asiatic origin, was in question.

Professor Ridgway believes that the promoters of this early civilisation may best be identified with the Pelagian race; and that this was a dark skinned people that had lived in Greece in a remote period. He holds that the Achaeans were a conquering race, of blond complexion, who invaded Greece during the later Mycenaean or Homeric period, coming probably from Epirus. He would identify this people as a branch of the great Celtic race, whose home was in west central Europe.

Be the exact antecedents of the Mycenaens and Achaeans what they may, the evidence seems clear that their civilisation came to a sudden termination. Their great cities were conquered and pillaged by people who were obviously far less developed, since they built primitive huts on the sites of the former palaces.

It is held that this cataclysm occurred about the year 1200 B. C., and it seems impossible to explain it, except on the supposition that a conquering host invaded Greece at this period. Presumably this was the people known to the Greeks of after time as the Dorians.

The tangible result of their invasion was that a dark age supervened in Greece comparable, perhaps, to that which supervened in Europe after the fall of Rome. This dark age, beginning thus about 1200 B. C., lasted for perhaps five centuries—let us say for twenty generations. This period of development sufficed to bring the conquering people to a high stage of civilisation,

preparing the way for the marvelous culture of the golden age of Athens.

The conquering host that was thus responsible for the overthrow of the old Mycenaean civilisation came, according to tradition, from the north. Whether their coming marked a great tribal migration or a succession of invasions is only conjectural. The fairest presumption is that the Dorians—if such we may call them—were thus crowded down into Greece by their various neighbors at the north, such neighbors as the Illyrians, Thesselonians, Macedonians, etc. There were parts of Greece, however, which they did not invade, or at least did not so fully conquer; prominent among these being the little peninsula of Attica. Here the civilisation of the elder day retained some of its old time features, accounting for the tradition, which Thucydides preserves for us, that Attica was the original seat of Greek civilisation.

The blood of the old Greeks did not remain unmixed in Attica, however, for this little peninsula became a favorite refuge for migrant Greeks of various tribes. Whoever was dissatisfied with his condition sought refuge here, and thus new blood was constantly infused into the old stock.

But the geographical conditions of Attica forbade the development of a large population there, and a constant outlet was sought by way of the sea. Throughout the post-Mycenaean period colonies were being sent out to the islands of the Aegean and even to the mainland of Asia Minor, and in the other direction to Southern Italy.

These colonies, mindful of their antecedents, remained loyal to the mother country and kept in

close commercial touch with her, while necessarily coming in close contact on the other hand with the neighboring peoples of Asia Minor and of Italy.

The stimulus of commercial and colonial life, and the wide mingling of ethnic elements thus brought about, led to that marvelous development of the sixth and fifth centuries B. C., which gave the world the most remarkable group of philosophers, historians, poets, artists, and statesmen known to any single period of history—the list that includes such names as Pythagoras, Anaxagores, Socrates, and Plato; Herodotus, Thucydides, and Xenophon; Sophocles, Aeschylus, Euripides, and Aristophanes; Phidias, Pericles, and Demosthenes.

The development of this marvelous galaxy of men of genius would be inexplicable had we not the history of the old races of highly developed culture into which many diverse elements of new blood were infused.

But here as elsewhere, the bloom time of a race is of relatively short duration. After the middle of the fourth century B. C. we hear no more of Attica as a center of creative culture. We may leave the peninsula of Greece, therefore, and briefly summerize the conditions that obtained in the sister peninsula of Italy off to the West, where the dominant people of the next epoch were nurtured.

THE ROMAN MELANGE

It will suffice to trace the ethnic origin of the Romans in the briefest terms. Liddell very well summarized it in the following words:

"It will appear that Latium formed a kind of focus, in which all the different races that in past centuries had been thronging into Italy converged. The Etruscans bordered on Latium to the west; the Sabines, with the Umbrians behind them, to the north; the Æquians and Volscians, Oscan tribes, to the northeast and east; while Hellenic communities are to be traced upon the coast lands. We should then expect beforehand to meet with a people formed by a commixture of divers tribes; and this expectation is confirmed.

"Tradition tells us that the aborigines of Latium mingled in early times with a people calling themselves Siculians; that these Siculians, being conquered and partly expelled from Italy, took refuge in the island which was afterwards called Sicily from them, but was at that time peopled by a tribe named Sicanians; that the conquering people were named Sacranians, and had themselves been forced down from the Sabine valleys in the neighborhood of Reate by Sabellian invaders; and that from this mixture of aborigines, Siculians, and Sacranians arose the people known afterwards by the name of Latins. Where all is uncertain, conjecture is easy. But all conjectures bear witness to the compound nature of the Latin nation."

The conditions under which this mixed population developed a race that dominated the world for several centuries are too well known to require rehearsal. From the present standpoint, it is pertinent to add, however, that when the fall of the Roman Empire came, it was coincident with the invasion of Italy by relatively barbaric tribes of the North; and that the new racial mingling that then took place blended the strains

of uncultured people with those of the decadent Romans, producing a new conglomerate race that required eight or ten centuries of development before it could take the initiative in pushing forward the arts of civilisation.

The purpose of the present sketch, however, is confined to the genesis of great nations of the past through the mixture of races, and does not take cognizance of the numerous causes that contributed to the decay of the nations after they have passed their prime.

A comprehensive survey of the subject would note that the best stock of the dominant race was constantly depleted by wars; and also, in the most modern view, by the influence of disease, notably malaria and the "plagues" in reducing the vitality of the race. But from the present standpoint it suffices to note that the Romans, the last of the great peoples of antiquity, furnished no exception to the rule that their virile stock, in time of national greatness, was of mixed racial origin, and that national decadence set in when the nation had maintained relative homogeneity for a few generations.

CHAPTER VI

SCIENCE AND CIVILIZATION

THE RISE OF MAN

THE word "civilization" is an obvious derivative of the Latin *civis,* a citizen, and *civilis,* pertaining to a citizen.

Etymologically speaking, then, it would be putting no undue strain upon the word to interpret it as having to do with the entire period of human progress since mankind attained sufficient intelligence and social unity to develop a system of government.

But in practise "civilization" is usually interpreted in a somewhat narrower sense, as having application solely to the most recent and comparatively brief period of time that has elapsed since the most highly developed races of men have used systems of writing.

This restricted usage is probably explicable, in part at least, by the fact that the word, tho distinctly modern in origin, is nevertheless older than the interpretation of social evolution that now finds universal acceptance. Only very recently has it come to be understood that primitive societies vastly antedating the historical period had attained relatively high stages of development and fixity, socially and politically. Now that this is understood, however, nothing but an arbitrary and highly inconvenient restriction of meanings can prevent us from speaking of the citizens of

these early societies as having attained certain stages of civilization.

It will be convenient, then, in outlining the successive stages of human progress here, to include under the comprehensive term "civilization" those long earlier periods of "savagery" and "barbarism" as well as the more recent period of higher development to which the word "civilization" is sometimes restricted.

Adequate proof that civilization as we now know it is the result of a long, slow process of evolution was put forward not long after the middle of the nineteenth century by the students of paleontology and of prehistoric archeology. A recognition of the fact that primitive man used implements of chipped flint, of polished stone, and of the softer metals for successive ages before he attained a degree of technical skill and knowledge that would enable him to melt iron led the Danish archeologists to classify the stages of human progress under these captions: The Rough Stone Age; the Age of Polished Stone; the Age of Bronze; and the Age of Iron.

These terms acquired almost universal recognition, and they retain popularity as affording a very broad outline of the story of human progress.

It is obviously desirable, however, to fill in the outlines of the story more in detail. To some extent it has been possible to do so, largely through the efforts of ethnologists who have studied the social conditions of existing races of savages. A recognition of the principle that, broadly speaking, progress has everywhere been achieved along the same lines and through the same sequence of changes makes it possible to

interpret the past history of the civilized races of to-day in the light of the present-day conditions of other races that are still existing under social and political conditions of a more primitive type. Such races as the Maoris and the American Indians have furnished invaluable information to the student of social evolution; and the knowledge thus gained has been extended and fortified by the ever-expanding researches of the paleontologist and archeologist.

Thus it has become possible to present with some confidence a picture showing the successive stages of human development during that long dark period when our prehistoric ancestor was advancing along the toilsome and tortuous but on the whole always uprising path from lowest savagery to the stage of relative enlightment at which we find him at the so-called "dawnings of history."

That he was for long ages a savage before he attained sufficient culture to be termed, in modern phraseology, a barbarian, admits of no question.

Equally little in doubt is it that other long ages of barbarism preceded the final ascent to civilization.

The precise period of time covered by these successive "ages" is of course only conjectural; but something like a million years may perhaps be taken as a safe minimal estimate.

At the beginning of this long period, the most advanced race of men must be thought of as a promiscuous company of pre-troglodytic mammals, at least partially arboreal in habit, living on uncooked fruits and vegetables, and possessed of no arts and crafts whatever—not even of the knowledge of the rudest implement.

At the end of the period, there emerges into the more or less clear light of history, a large-brained being living in houses of elaborate construction, supplying himself with divers luxuries through the aid of a multitude of elaborate handicrafts, associated with his fellows under the sway of highly organized governments, and satisfying esthetic needs through the practise of pictorial and literary arts of a high order.

How was this amazing transformation brought about?

If an answer can be found to that query, we shall have a clue to all human progress, not only during the prehistoric but also during the historic period; for we may well believe that recent progress has not departed from the scheme of development impressed on humanity during that long apprenticeship.

Ethnologists believe that an answer can be found. They believe that the metamorphosis from beast-like savage to cultured civilian may be proximally explained (certain potentialities and attributes of the species being taken for granted) as the result of accumulated changes that found their initial impulses in a half dozen or so of practical inventions.

Stated thus the explanation seems absurdly simple. Confessedly it supplies only a proximate, not a final, analysis of the forces impelling mankind along the pathway of progress. But it has the merit of tangibility; it presents certain highly important facts of human history vividly; and it furnishes a definite and fairly satisfactory basis for marking successive stages of incipient civilization.

SIX PREHISTORIC PERIODS

In outlining the story of primitive man's advancement upon such a basis, we may follow the scheme of one of the most philosophical of ethnologists, Lewis H. Morgan, who thirty years ago made a provisional analysis of the prehistoric period that still remains among the most satisfactory attempts in this direction. Morgan divided the entire epoch of man's progress from bestiality to civilization into six successive periods, which he named respectively the Older, Middle, and Later periods of Savagery, and the Older, Middle, and Later periods of Barbarism.

The first of these periods, when mankind were in the lower status of savagery, comprises the epoch when articulate speech was being developed. Our ancestors of this epoch inhabited a necessarily restricted tropical territory, and subsisted upon raw nuts and fruits. They had no knowledge of the use of fire. All existing races of men had advanced beyond this condition before the opening of the historical period.

The Middle Period of Savagery began with a knowledge of the uses of fire. This wonderful discovery enabled the developing race to extend its habitat almost indefinitely, and to include flesh, and in particular fish, in its regular dietary. Man could now leave the forests, and wander along the shores and rivers, migrating to climates less enervating than those to which he had previously been confined. Doubtless he became an expert fisher, but he was as yet poorly equipped for hunting, being provided, probably, with no weapon more formidable than a crude hatchet and a roughly fashioned spear. The primitive races of

Australia and Polynesia had not advanced beyond this middle status of savagery when they were discovered a few generations ago.

It is obvious, then, that in dealing with the further progress of nascent civilization we have to do with certain favored portions of the race, which sought out new territories and developed new capacities while many tribes of their quandam peers remained static and hence by comparison seemed to retrograde.

The next great epochal discovery, by virtue of which a portion of the race advanced to the Upper Status of Savagery, was that of the bow and arrow,—a truly wonderful implement. The possessor of this device could bring down the fleetest animal and could defend himself against the most predacious. He could provide himself not only with food but with materials for clothing and for tent-making, and thus could migrate at will back from the seas and large rivers, and far into inhospitable but invigorating temperate and sub-Arctic regions. The meat diet now for the first time freely available probably contributed, along with the stimulating climate, to increase the physical vigor and courage of this highest savage, thus urging him along the paths of progress.

Nevertheless many tribes came thus far and no farther, as witness the Athapascans of the Hudson's Bay Territory and the Indians of the valley of the Columbia.

We now come to the marvelous discovery that enabled our ancestor to make such advances upon the social conditions of his forebears as to entitle him, in the estimate of his remote descendants, to be considered as putting savagery behind him

and as entering upon the Lower Status of Barbarism.

The discovery in question had to do with the practise of the art of making pottery.

Hitherto man had been possessed of no permanent utensils that could withstand the action of fire. He could not readily boil water except by some such cumbersome method as the dropping of heated stones into a wooden or skin receptacle. The effect upon his dietary of having at hand earthen vessels in which meat and herbs could be boiled over a fire must have been momentous. Various meats and many vegetables become highly palatable when boiled that are almost or quite inedible when merely roasted before a fire. Bones, sinews, and even hides may be made to give up a modicum of nutriment in this way; and doubtless barbaric man, before whom starvation days loomed threateningly, found the crude pot an almost perennial refuge.

And of course its use as a cooking utensil was only one of many ways in which the newly discovered mechanism exerted a civilizing influence.

The next great progressive movement, which carried man into the Middle Status of Barbarism, is associatel with the domestication of animals in the Eastern hemisphere, and with the use of irrigation in cultivating the soil and of adobe bricks and stone in architecture in the Western hemisphere.

The dog was probably the first animal to be domesticated, but the sheep, the ox, the camel, and the horse were doubtless added in relatively rapid succession, so soon as the idea that captive

animals could be of service had been clearly conceived.

Man now became a herdsman, no longer dependent for food upon the precarious chase of wild animals. Milk, procurable at all seasons, made a highly important addition to this dietary.

With the aid of camel and horse he could traverse wide areas hitherto impassable, and come in contact with distant peoples. Thus commerce came to play an extended rôle in the dissemination of both commodities and ideas. In particular the nascent civilization of the Mediterranean region fell heir to numerous products of farther Asia,—gums, spices, oils, and most important of all, the cereals. The cultivation of the latter gave the finishing touch to a comprehensive and varied diet, while emphasizing the value of a fixed abode.

For the first time it now became possible for large numbers of people to form localized communities. A natural consequence was the elaboration of political systems, which, however, proceeded along lines already suggested by the experience of earlier epochs.

All this tended to establish and emphasize the idea of nationality, based primarily on blood-relationship; and at the same time to develop within the community itself the idea of property, —that is to say, of valuable or desirable commodities which have come into the possession of an individual through his enterprise or labor, and which should therefore be subject to his voluntary disposal. At an earlier stage of development, all property had been of common, and not of individual, ownership.

It appears, then, that our mid period barbarism

had attained—if the verbal contradiction be permitted—a relatively high state of civilization.

There remained, however, one master craft of which he had no conception. This was the art of smelting iron. When, ultimately, his descendants learned the wonderful secrets of that art, they rose in consequence to the Upper Status of Barbarism.

This culminating practical invention, it will be observed, is the first of the great discoveries with which we have to do that was not primarily concerned with the question of man's food supply. Iron, to be sure, has abundant uses in the same connection, but its most direct and obvious utilities have to do with weapons of war and with implements calculated to promote such arts of peace as house-building, road making, and the construction of vehicles.

Wood and stone could now be fashioned as never before. Houses could be built and cities walled with unexampled facility; to say nothing of the making of a multitude of minor implements and utensils hitherto quite unknown, or at best rare and costly. Nor must we overlook the esthetic influence of the possession of edged implements with which wood and stone could readily be sculptured, when placed in the hands of a race that had long been accustomed to scratch the semblance of living forms on bone or ivory and to fashion crude images of clay. In a word, man the "tool-making animal," was now for the first time provided with tools worthy of his wonderful hands and yet more wonderful brain.

Thus through the application of one revolutionary invention after another, the most advanced

races of men had arrived, after long ages of effort, at a relatively high stage of development. A very wide range of experience had enabled man to evolve a complex body politic based on a fairly secure social foundation, and his brain had correspondingly developed into a relatively efficient and stable organ of thought. But as yet he had devised no means of communicating freely with other people at a distance except through the medium of verbal messages; nor had he any method by which he could transmit his experience to posterity more securely than by fugitive and fallible oral traditions.

A vague symbolization of his achievements was preserved from generation to generation in myth-tale and epic, but he knew not how to make permanent record of his history.

Until he could devise a means to make such record, he must remain, in the estimate of his descendants, a barbarian, tho he might be admitted to have developed a highly organized and even in a broad sense a cultured society.

At length, however, this last barrier was broken. Some race or races devised a method of symbolizing events and ultimately of making even abstruse ideas tangible by means of graphic signs.

In other words, a system of writing was developed.

Man thus achieved a virtual conquest over Time as he had earlier conquered Space. He could now transmit the record of his deeds and his thoughts to remote posterity. Thus he stood at the portals of what later generations would term secure history. He had graduated out of barbarism, and

become in the narrower sense of the word a Civilized being.

Henceforth his knowledge, his poetical dreamings, his moral aspirations might be recorded in such form as to be read not merely by his contemporaries but by successive generations of remote posterity.

The inspiring character of such a message is obvious. The validity of making this great culminating intellectual achievement the test of "civilized" existence need not be denied. But we should ill comprehend the character of the message which the earlier generations of civilized beings transmit to us from the period which we term the "dawning of history" did we not bear constantly in mind the long series of progressive stages of "savagery" and "barbarism" that of necessity preceded the final stage of "civilization" proper.

The achievements of those earlier stages afforded the secure foundation for the progress of the future.

A multitude of minor arts, in addition to the important ones just outlined, had been developed; and for a long time civilized man was to make no other epochal addition to the list of accomplishments that came to him as a heritage from his barbaric progenitor. Indeed, even to this day the list of such additions is not a long one, nor, judged in the relative scale, so important as might at first thought be supposed.

Whoever considers the subject carefully must admit the force of Morgan's suggestion that man's achievements as a barbarian, considered in their relation to the sum of human progress, "transcend, in relative importance, all his subsequent works."

EPOCHAL DISCOVERIES OF THE HISTORICAL PERIOD

Without insisting on this comparison, however, let us ask what discoveries and inventions man has made within the historical period that may fairly be ranked with the half dozen great epochal achievements that have been put forward as furnishing the keys to all the progress of the prehistoric periods.

In other words, let us sketch the history of progress during the ten thousand years or so that have elapsed since man learned the art of writing, adapting our sketch to the same scale which we have already applied to the unnumbered millenniums of the prehistoric period.

The view of world-history thus outlined will be a very different one from what might be expected by the student of national history; but it will present the essentials of the progress of civilization in a suggestive light.

Without pretending to fix an exact date,—which the historical records do not at present permit,—we may assume that the most advanced race of men elaborated a system of writing, not less than six thousand years before the beginning of the Christian era. Holding to the terminology already suggested for the earlier periods, we may speak of man's position during the ensuing generations as that of the First or Lowest Status of Civilization.

If we review the history of this period, we shall find that it extends unbroken over a stretch of at least four or five thousand years.

During the early part of this period such localized civilizations as those of the Egyptians, the

Sumerians, the Babylonians, and the Hittites rose, grew strong, and passed beyond their meridian.

This suggests that we must now admit the word "civilization" to yet another definition, within its larger meaning; we must speak of "a civilization," as that of Egypt, of Babylonia, of Assyria, and we must understand thereby a localized phase of society bearing the same relation to Civilization as a whole that a wave bears to the ocean or a tree to the forest. Such other localized civilizations as those of Phenicia, Carthage, Greece, Rome, Byzantium, the Sassanids, in due course waxed and waned, leaving a tremendous imprint on national history, but creating only minor and transitory ripples in the great ocean of Civilization.

Progress in the elaboration of the details of earlier methods and inventions there was, as a matter of course.

Some nation, probably the Phenicians, gave a new impetus to the art of writing by developing a phonetic alphabet; but this achievement, remarkable as it was in itself, added nothing fundamental to human capacity. Literature had previously flourished through the use of hieroglyphic and syllabic symbols; and the Babylonian syllabics continued in vogue throughout western Asia for a long time after the Phenician alphabet had demonstrated its intrinsic superiority.

Similarly the art of Egyptian and Assyrian and Greek was but the elaboration and perfection of methods that barbaric man had practised away back in the days when he was a cave-dweller. The weapons of warfare of Greek and Roman were the spear and the bow and arrow that their

ancestors had used in the period of savagery, aided by sword and helmet dating from the upper period of barbarism. Greek and Roman government at their best were founded upon the system of *gentes* that barbaric man had profoundly studied—as witness, for example, the federal system of the barbaric Iroquois Indians existing in America before the coming of Columbus.

And if the Greeks had better literature, the Romans better roads and larger cities than their predecessors, these are but matters of detailed development, the like of which had marked the progress of the more important arts and the introduction of less important ancillary ones in each antecedent period. The ax of steel is no new implement, but a mere perfectionment of the ax of chipped flint. The *Iliad* represents the perfectionment of an art that unnumbered generations of barbarians practised before their camp-fires.

Thus for six or seven thousand years after man achieved civilization there was rhythmic progress in many lines but there came no great epochal invention to usher in a new ethnic period.

Then, toward the close of what historians of to-day are accustomed to call the Middle Ages, there appeared in rapid sequence three or four inventions and a great scientific discovery that, taken together, were destined to change the entire aspects of European civilization.

The inventions were gunpowder, the mariner's compass, paper, and the printing press, three of which appear to have been brought into Europe by the Moors, whether or not they originated in the remote East.

The scientific discovery which must be coupled

with these inventions was the Copernican demonstration that the sun and not the earth is the center of our planetary system.

The generations of men that found themselves (1) confronted with the revolutionary conception of the universe given by the Copernican theory; (2) supplied with the new means of warfare provided by gunpowder; (3) equipped with an undreamed-of guide across the waters of the earth; and (4) enabled to promulgate knowledge with unexampled speed and cheapness through the aid of paper and printing-press—such generations of men might well be said to have entered upon a new ethnic period. The transitions in their mode of thought and in their methods of practical life were as great as can be supposed to have resulted, in an early generation, from the introduction of iron, or in a yet earlier from the invention of the bow and arrow.

So the Europeans of about the fifteenth century of the Christian Era may be said to have entered upon the second or Middle Status of Civilization.

The new period was destined to be a brief one. It had compassed only about four hundred years when, toward the close of the eighteenth century, James Watt gave to the world the perfected steam engine. Almost contemporaneously Arkwright and Hargreaves developed revolutionary processes of spinning and weaving by machinery. Meantime James Hutton and William Smith and their successors on one hand and Erasmus Darwin, François Lamarck, and (a half century later) Charles Darwin on the other turned men's ideas topsyturvy by demonstrating that the world as the abiding place of animals and man is enormously

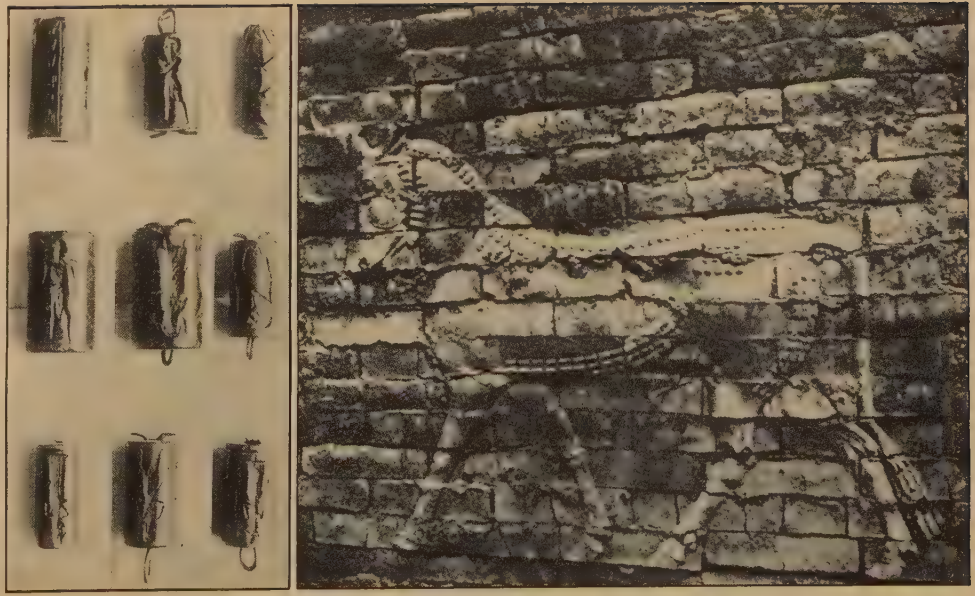
old, and that man himself, instead of deteriorating from a single perfect pair six thousand years removed, has ascended from bestiality through a slow process of evolution extending over hundreds of centuries.

The revolution in practical life and in the mental life of our race that followed these inventions and this new presentation of truth probably exceeded in suddenness and in its far-reaching effects the metamorphosis effected at any previous transition from one ethnic period to another. The men of the nineteenth century, living now in the period that may be termed the Upper Status of Civilization, saw such changes effected in the practical affairs of their every-day lives as had not been wrought before during the entire historical period. Their fathers had traveled in vehicles drawn by horses, quite as their remoter ancestors had done since the time of higher barbarism.

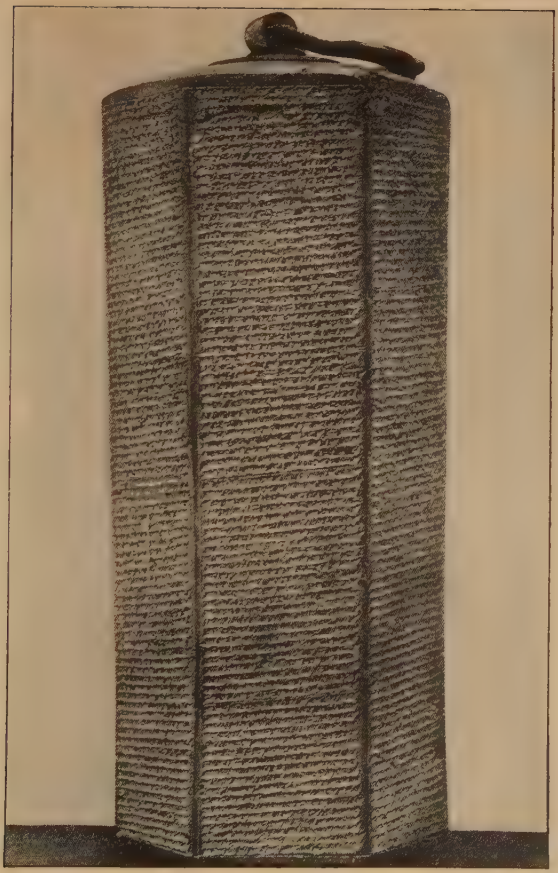
It may be doubted whether there existed in the world in the year 1800 a postal service that could compare in speed and efficiency with the express service of the Romans of the time of Cæsar; far less was there a telegraph service that could compare with that of the ancient Persians. Nor was there a ship sailing the seas that a Phenician trireme might not have overhauled.

But now within the lifetime of a single man the world was covered with a network of steel rails on which locomotives drew gigantic vehicles, laden with passengers, at an hourly speed almost equalling Cæsar's best journey of a day; over the land and under the seas were stretched wires along which messages coursed from continent to

MONUMENTS OF ANCIENT CIVILIZATION OF EGYPT (BELOW) AND BABYLONIA



BULL ON THE GATE OF ISTAR AT THE PALACE OF NEBUCHADNEZZAR AT BABYLON, AND BABYLONIAN CYLINDRICAL SEALS



BAKED CLAY ASSYRIAN CYLINDER OF 701 B. C.
TELLING OF SENNACHERIB'S CAMPAIGN
AGAINST JERUSALEM

ASSURBANIPAL, KING OF ASSYRIA 668-626 B. C., BANQUETING WITH HIS QUEEN IN THE GARDEN, AND LION-HUNTING, AS SHOWN IN CONTEMPORARY BAS-RELIEFS

PREHISTORIC MONUMENTS: MENHIRS AT ERDEVAN, FRANCE, FROM THE UNDATED "AGE OF MONOLITHS"

PREHISTORIC MONUMENTS: THE ALIGNMENT AT MENEC, CARNAS, FRANCE

PREHISTORIC MONUMENTS: TYPICAL DOLMENS (ONE AT LEFT FALLEN)
BELIEVED TO BE PRIMITIVE SEPULTURES

PREHISTORIC MONUMENTS: BROKEN MONOLITH AT LOCHARIAQUER, BRITTANY, THE LARGEST MENHIR IN THE WORLD

continent literally with the speed of lightning; and the waters of the earth were made to teem with gigantic craft propelled without sail or oar at a speed which the Phenician captain of three thousand years ago and the English captain of the eighteenth century would alike have held incredible.

There is no need to give further details here of the industrial revolutions that have been achieved in this newest period of civilization, since in their broader outlines at least they are familiar to every one. Nor need we dwell upon the revolution in thought whereby man has for the first time been given a clear inkling as to his origin and destiny.

It suffices to point out that such periods of fermentation of ideas as this suggests have probably always been concomitant with those outbursts of creative genius that gave the world the practical inventions upon which human progress has been conditioned.

The same attitude of receptivity to new ideas is prerequisite to one form of discovery as to the other.

Nor, it may be added, can either form of idea become effective for the progress of civilization except in proportion as a large body of any given generation are prepared to receive it. Doubtless here and there a dreamer played with fire, in a literal sense, for generations before the utility of fire as a practical aid to human progress came to be recognized in practise. And—to seek an illustration at the other end of the scale—we know that the advanced thinkers of Greece and Rome believed in the antiquity of the earth and in the

evolution of man two thousand years before the coming of Darwin.

We have but partly solved the mysteries of the progress of civilization, then, when we have pointed out that each tangible stage of progress owed its initiative to a new invention or discovery of science.

To go to the root of the matter we must needs explain how it came about that a given generation of men was in mental mood to receive the new invention or discovery.

The pursuit of this question would carry us farther into the realm of communal and racial psychology—to say nothing of the realm of conjecture—than comports with the present purpose. It must suffice to say that alertness of mind—that all mentality—is, in the last analysis, a reaction to the influence of the environment.

It follows that man may subject himself to new influences and thus give his mind a new and important stimulus by changing his habitat.

A fundamental secret of progress is revealed in this fact. Man probably never would have evolved from savagery had he remained in the tropics where he doubtless originated. But successive scientific inventions enabled him, as has been suggested, to migrate to distant latitudes, and thus more or less involuntarily to become the recipient of new creative and progressive impulses. After migrations in many directions had resulted in the development of divers races, each with certain capacities and acquirements due to its unique environment, there was opportunity for the application of the principle of environmental stimulus

in an indirect way, through the mingling and physical intermixture of one race with another.

Each of the great localized civilizations of antiquity appears to have owed its prominence in part at least—perhaps very largely—to such intermingling of two or more races.

Each of these civilizations began to decay so soon as the nation had remained for a considerable number of generations in its localized environment and had practically ceased to receive accretions from distant races at approximately the same stage of development.

There is a suggestive lesson for present-day civilization in that thought-compelling fact.

Further evidence of the application of the principle of environmental stimulus, operating in the changed habitat and racial intermixture, is furnished by the virility of the Colonial peoples of our own day. The receptiveness to new ideas and the rapidity of material progress of Americans, South Africans, and Australians is proverbial. No one doubts, probably, that one or another of these countries will give a new stimulus to the progress of civilization, through the promulgation of some great epochal discovery, in the not distant future.

Again, the value of racial intermingling is shown in the long-continued vitality of the British nation, which is explicable, in some measure at least, by the fact that the Celtic element held aloof from the Anglo-Saxon element century after century sufficiently to maintain racial integrity, yet mingled sufficiently to give and receive the fresh stimulus of "new blood."

It is interesting in this connection to examine

the map of Great Britain with reference to the birthplaces of the men named above as being the originators of the inventions and discoveries that made the close of the eighteenth century memorable as ushering in a new ethnic era.

It may be added that these names suggest yet another element in the causation of progress: the fact, namely, that, however necessary racial receptivity may be to the dynamitic upheaval of a new ethnic era, it is *individual* genius after all that applies the detonating spark.

SOCIAL AND POLITICAL PROGRESS

Without further elaboration of this aspect of the subject, it may be useful to recapitulate the analysis of the evolution of civilization above given.

It appears that the entire period of human progress up to the present may be divided into nine periods which, if of necessity more or less arbitrary, yet are not without certain warrant of logic. They may be defined as follows: (1) The Lower Period of Savagery, terminating with the discovery and application of the uses of fire. (2) The Middle Period of Savagery, terminating with the invention of the bow and arrow. (3) The Upper Period of Savagery, terminating with the invention of pottery. (4) The Lower Period of Barbarism, terminating with the domestication of animals. (5) The Middle Period of Barbarism, terminating with the discovery of the process of smelting iron ore. (6) The Upper Period of Barbarism, terminating with the development of a system of writing meeting the requirements of literary composition. (7) The First Period of

Civilization (proper), terminating with the introduction of gunpowder. (8) The Second Period of Civilization, terminating with the invention of a practical steam engine. (9) The Upper Period of Civilization, which is still in progress, but which, as will be suggested in a moment, is probably nearing its termination.

It requires but a glance at the characteristics of these successive epochs to show the ever-increasing complexity of the inventions that deliminate them and of the conditions of life that they connote.

Were we to attempt to characterize in a few phrases the entire story of achievement thus outlined, we might say that during the three stages of Savagery man was attempting to make himself master of the geographical climates. His unconscious ideal was to gain a foothold, and the means of sustenance, in every zone.

During the three periods of Barbarism, the ideal of conquest was extended to the beasts of the field, the vegetable world, and the mineral contents of the earth's crust.

During the three periods of Civilization proper the ideal of conquest has become still more intellectual and subtle, being now extended to such abstractions as an analysis of speech-sounds, and to such intangibles as expanding gases and still more elusive electric currents: in other words, to the forces of nature, no less than to tangible substances.

Hand in hand with this growing complexity of man's relations with the external world has gone a like increase of complexity in the social and political organizations that characterize man's

relations with his fellow men. In savagery the family expanded into the tribe; in barbarism the tribe developed into the nation.

The epoch of civilization proper is aptly named, because it has been a time in which citizenship, in the narrower national significance, has probably been developed to its apogee.

Throughout this period, in every land, the highest virtue has been considered to be patriotism,—by which must be understood, an instinctive willingness on the part of every individual to defend even with his life the interests of the nation into which he chances to be born, regardless of whether the national cause in which he struggles be in any given case good or bad, right or wrong.

The communal judgment of this epoch pronounces any man a traitor who will not uphold his own nation even in a wrong cause—and the word "traitor" marks the utmost brand of ignominy.

But while the idea of nationality has thus been accentuated, there has been a never-ending struggle within the bounds of the nation itself to adjust the relations of one citizen to another. The ideas that might makes right, that the strong man must dominate the weak, that leadership in the community properly belongs to the man who is physically most competent to lead—these ideas were a perfectly natural, and indeed an inevitable, outgrowth of the conditions under which man fought his way up through savagery and barbarism.

Man in the first period of civilization inherited these ideas, along with the conditions of society that were their concomitants.

So throughout the periods when the Oriental civilizations of Egypt and Babylonia and Assyria and Persia were dominant, a despotic form of government was accepted as the natural order of things. It does not appear that any other form was even considered as a practicality. A despot might indeed be overthrown, but only to make way for the coronation of another despot. A little later the Greeks and Romans modified the conception of a heaven-sent individual monarch; but they went no farther than to substitute a heaven-favored community with specially favored groups (*Patricii*) within this community.

With this, national egoism reached its climax; for each people regarded its own citizens as the only examplars of civilization, openly branding all the rest of the world as "barbarians,"—fit subjects for the exaction of tribute, or for the imposition of the bonds of actual slavery.

During the Middle Ages there was a reaction toward individualism as opposed to nationalism; but the entire system of feudalism, with its clearly recognized conditions of overlordship and of vassaldom, gave expression no less clearly than Oriental despotism and classical "democracy" had done to the idea of individual inequality and divergence of moral and legal status based on natural inheritance.

Thus this idea, a reminiscence of barbarism, maintained its dominance throughout the first period of civilization.

But gunpowder, marking the transition to the second period of civilization, came as a great leveling influence. With its aid the weakest peasant might prove more than a match for the

most powerful knight. Before its assaults the castle of the lord ceased to be an impregnable fortress. And while gunpowder thus leveled down the power of the mighty, the printing press leveled up the intelligence, and hence the power and influence, of the lowly.

Meantime the mariner's compass opened up new territories beyond the seas, and in due course men of lowly origin were seen to attain to wealth and power through commercial pursuits, thus tending to break in upon the established social order.

In the colonial territories themselves all men were subjected more or less to the same perils and dependent upon their own efforts. Success and prominence in the community came not as a birthright, but as the result of demonstrated fitness. The great lesson that the interests of all members of a community are in the last analysis, mutual could be more clearly distinguished in these small colonies than in larger and older bodies politic.

Through various channels, therefore, in the successive generations of this middle period of civilization, the idea gained ground that intelligence and moral worth rather than physical prowess should be the test of greatness; that it is encumbent on the strong, in the interests of the body politic, to protect the weak; and that, in the long run, the best interests of the community are conserved if all its members, without exception, are given moral equality before the law.

This idea of equal rights and privileges for all members of the community—for each individual "the greatest amount of liberty consistent with a like liberty of every other individual"—first found

expression as a philosophical doctrine toward the close of the eighteenth century; at which time also tentative efforts were made to put it into practise. It may be said, therefore, to represent the culminating sociological doctrine of the middle period of civilization,—the ideal toward which all the influences of the period had tended to impel the race.

It will be observed, however, that this ideal of individual equality within the body politic in no direct wise influences the status of the body politic itself as the center of a localized civilization that may be regarded as in a sense antagonistic to all other similarly localized civilizations. If there were any such influence, it would rather operate in the direction of accentuating the patriotism of the member of a democratical community, as against that of the subject of a despot, through the sense of personal responsibility developed in the former.

The developments of the middle period of civilization can not be considered, therefore, to have tended to decrease the spirit of nationality, with its concomitant penalty of what is sometimes called provincialism.

The history of this entire period, as commonly presented, is largely made up of the records of international rivalries and jealousies, perennially culminating in bitterly contested wars.

It was only toward the close of the epoch that the desirability of free commercial intercourse among nations began to find expression as a philosophical creed, through the efforts of Quesnay and his followers; and the doctrine that both

parties to an international commercial transaction are gainers thereby found its first clear expression in the year 1776 in the pages of Condillac and of Adam Smith.

But the discoveries that ushered in the third period of civilization were destined to work powerfully from the outset for the breaking down of international barriers, tho of course their effects would not be at once manifest. Thus the substitution of steam power for water power, besides giving a tremendous impetus to manufacturing in general, mapped out new industrial centers in regions that nature had supplied with coal but not always with other raw materials.

To note a single result, England became the manufacturing center of the world, drawing its raw materials from every corner of the globe; but in so doing it ceased to be self-supporting as regards the production of food-supplies.

While growing in national wealth, as a result of the new inventions, England has therefore lost immeasurably in national self-sufficiency and independence; having become in large measure dependent upon other countries both for the raw materials without which her industries must perish and for the foods to maintain the very life of her people.

What is true of England in this regard is of course true in greater or less measure of all other countries.

Everywhere, thanks to the new mechanisms that increase industrial efficiency, there has been an increasing tendency to specialization; and since the manufacturer must often find his raw mate-

rials in one part of the world and his markets in another, this implies an ever-increasing intercommunication and interdependence between the nations. This spirit is obviously fostered by the new means of transportation by locomotive and steamship, and by the electric communication that enables the Londoner, for example, to transact business in New York or in Tokio with scarcely an hour's delay; and that puts everyone in touch at to-day's breakfast-table with the happenings of the entire world.

Thanks to the new mechanisms, national isolation is no longer possible; globe-trotting has become a habit with thousands of individuals of many nations; and Orient and Occident, representing civilizations that for thousands of years were almost absolutely severed and mutually oblivious of each other have been brought again into close touch for mutual education and betterment.

The Western mind has learned with amazement that the aforetime *Terra Incognita* of the Far East has nurtured a gigantic civilization having ideals in many ways far different from our own.

The Eastern mind has proved itself capable, in self-defense, of absorbing the essential practicalities of Western civilization within a single generation.

Some of the most important problems of world-civilization of the immediate future hinge upon the mutual relations of these two long-severed communities, branched at some early stage of progress to opposite hemispheres of the globe, but now brought by the new mechanisms into daily and even hourly communication.

MAN AS COSMOPOLITE

While the new conditions of the industrial world have thus tended to develop a new national outlook, there has come about, as a result of the scientific discoveries already referred to, a no less significant broadening of the mental and spiritual horizons.

Here also the trend is away from the narrowly egoistic and toward the cosmopolitan view.

About the middle of the nineteenth century, Dr. Pritchard declared that many people debated whether it might not be permissible for the Australian settlers to shoot the natives as food for their dogs; some of the disputants arguing that savages were without the pale of human brotherhood. To-day the thesis that all mankind are one brotherhood needs no defense. The most primitive of existing aborigines are regarded merely as brethren who through some defect or neglect of opportunity have lagged behind in the race.

Similarly the defective and criminal classes that make up so significant a part of the population of even our highest present-day civilizations, are no longer regarded with anger or contempt, as beings who are suffering just punishment for wilful transgressions, but are considered as the pitiful victims of hereditary and environmental influences that they could neither choose nor control. Insanity is no longer thought of as demoniac possession, but as the most lamentable of diseases.

The changed attitude toward savage races and defective classes affords tangible illustrations of a fundamental transformation of point of view which doubtless represents the most important

result of the operation of new scientific knowledge in the course of the nineteenth century. It is a transformation that is only partially effected as yet, to be sure; but it is rapidly making headway, and when fully achieved it will represent, probably, the most radical metamorphosis of mental view that has taken place in the entire course of the historical period.

The essence of the new view is this: to recognize the universality and the invariability of natural law; stated otherwise, to understand that the word "supernatural" involves a contradiction of terms and has in fact no meaning.

Whoever has grasped the full import of this truth is privileged to sweep mental horizons wider by far than ever opened to the view of any thinker of an earlier epoch.

He is privileged to forecast, as the sure heritage of the future, a civilization freed from the last ghost of superstition—an Age of Reason in which mankind shall at last find refuge from the hosts of occult and invisible powers, the fearsome galaxies of deities and demons, which have haunted him thus far at every stage of his long journey through savagery, barbarism, and civilization.

Doubtless here and there a thinker, even in the barbaric eras, may have realized that these ghosts that so influenced the every-day lives of his fellows were but children of the imagination.

But the certainty that such is the case could not have come with the force of demonstration even to the most clear-sighted thinker until nineteenth century science had investigated with penetrating vision the realm of molecule and atom;

had revealed the awe-inspiring principle of the conservation of energy; and had offered a comprehensible explanation of the evolution of one form of life from another, from nomad to man, that did not presuppose the intervention of powers more "supernatural" than those that operate about us everywhere to-day.

The stupendous import of these new truths could not, of course, make itself evident to the generality of mankind in a single generation, when opposed to superstitions of a thousand generations' standing. But the new knowledge has made its way more expeditiously than could have been anticipated; and its effects are seen on every side, even where its agency is scarcely recognized.

As a single illustration, we may note the familiar observation that the entire complexion of orthodox teaching of religion has been more altered in the past fifty years than in two thousand years before.

This of course is not entirely due to the influence of physical and biological science;—no effect has a unique cause in the complex sociological scheme. Archeology, comparative philology, and textual criticism have also contributed their share; and the comparative study of religions has further tended to broaden the outlook and to make for universality, as opposed to insularity, of view. It is coming to be more and more widely recognized that all theologies are but the reflex of the more or less faulty knowledge of the times in which they originate; that the true and abiding purpose of religion should be the practical betterment of humanity,—the advancement of civilization in the best sense of the word; and that this end may

perhaps be best subserved by different systems of theology, adapted to the varied genius of different times and divers races.

Wherefore there is not the same enthusiastic desire to-day that found expression a generation ago, to impose upon the cultured millions of the East a religion that seems to them alien to their manner of thought, unsuited to their needs, and less distinctly ethical in teaching than their own religions.

Such are but a few of the illustrations that might be cited from many fields to suggest that the mind of our generation is becoming receptive to a changed point of view that augurs the coming of a new ethnic era.

If one may be permitted to enter very tentatively the field of prophecy, it seems not unlikely that the great revolutionary invention which will close the third period of civilization and usher in a new era is already being evolved. It seems not over-hazardous to predict that the airship, in one form or another, is destined to be the mechanism that will give the new impetus to human civilization; that the next era will have as one of its practical ideals the conquest of the air; and that this conquest will become a factor in the final emergence of humanity from the insularity of nationalism to the broad view of cosmopolitanism, toward which, as we have seen, the tendencies of the present era are merging.

That the gap to be covered is a vastly wide one no one need be reminded who recalls that the civilized nations of Europe, together with America and Japan, are at present accustomed to spend more than fifteen hundred million dollars each

year merely that they may keep armaments in readiness to fly at one another's throats should occasion arise.

Formidable as these armaments now seem, however, the developments of the not very distant future will probably make them quite obsolete; and sooner or later, as science develops yet more deadly implements of destruction, the time must come when communal intelligence will rebel at the suicidal folly of the international attitude that characterized, for example, the opening decade of the twentieth century.

At some time, after the First Period of Cosmopolitanism shall be ushered in as a tenth ethnic period, it will come to be recognized that there is a word fraught with fuller meanings even than the word patriotism.

That word is—Humanitarism.

The enlightened generation that realizes the full implications of that word will doubtless marvel that their ancestors of the Third Period of Civilization should have risen up as nations and slaughtered one another by thousands to settle a dispute about a geographical boundary. Such a procedure will appear to have been quite as barbarous as the cannibalistic practises of their yet more remote ancestors, and distinctly less rational, since cannibalism might sometimes save its practiser from starvation, whereas warfare of the civilized type was a purely destructive agency.

Equally obvious must it appear to the Cosmopolite of some generation of the future that quality rather than mere numbers must determine the efficiency of any given community.

Race suicide will then cease to be a bugbear;

and it will no longer be considered rational to keep up the census at the cost of propagating low orders of intelligence, to feed the ranks of paupers, defectives, and criminals.

On the contrary it will be thought fitting that man should become the conscious arbiter of his own racial destiny to the extent of applying whatever laws of heredity he knows or may acquire in the interests of his own species, as he has long applied them in the case of domesticated animals.

The survival and procreation of the unfit will then cease to be a menace to the progress of civilization.

It does not follow that all men will be brought to a dead level of equality of body and mind, nor that individual competition will cease; but the average physical and mental status of the race will be raised immeasurably through the virtual elimination of that vast company of defectives which to-day constitutes so threatening an obstacle to racial progress. There are millions of men in Europe and America to-day whose whole mental equipment—despite the fact that they have been taught to read and write—is far more closely akin to the average of the Upper Period of Barbarism than to the highest standards of their own time; and these defective or atavistic persons have on the average more offspring than are produced by the more highly cultured and intelligent among their contemporaries.

"Race suicide" is thereby prevented, but the progress of civilization is no less surely handicapped.

We may well believe that the Cosmopolite of the future, aided by science, will find rational

means to remedy this strange illogicality. In so doing he will exercise a more consciously purposeful function, and perhaps a more directly potent influence, in determining the line of human progress than he has hitherto attempted to assume, notwithstanding the almost infinitely varied character of the experiments through which he has worked his way from savagery to civilization.

A WORLD CYCLE

All these considerations tend to define yet more clearly the ultimate goal toward which the progressive civilization of past and present appears to be trending.

The contemplation of this goal brings into view the outlines of a vastly suggestive evolutionary cycle. For it appears that the social conditions of Cosmopolite man, so far as the present-day view can predict it, will represent a state of things, magnified to world-dimensions, that was curiously adumbrated by the social system of the earliest savage.

At the very beginning of the journey through savagery, mankind, we may well believe, consisted of a limited tribe, representing no great range or variety of capacity, and an almost absolute identity of interests. Thanks to this community of interests—which was fortified by the recognition of blood relationship among all members of the tribe—a principle which we now define as "the greatest ultimate good to the greatest number" found practical, even if unwitting, recognition; and therein lay the germs of all the moral development of the future. But obvious identity of interests could be recognized only so long as the

tribe remained very small. So soon as its numbers became large, patent diversities of interest, based on individual selfishness, must appear, to obscure the larger harmony.

And as savage man migrated hither and yon, occupying new regions and thus developing new tribes and ultimately a diversity of "races," all idea of community of interests, as between race and race, must have been absolutely banished. It was the obvious and patent fact that each race was more or less at rivalry, in disharmony, with all the others. In the hard struggle for subsistence, the expansion of one race meant the downfall of another.

So far as any principle of "greatest good" remained in evidence, it applied solely to the members of one's own community, or even to one's particular phratry or gens.

Barbaric men, thanks to his conquest of animal and vegetable nature, was able to extend the size of the unified community, and hence to develop through diverse and intricate channels the application of the principle of "greatest good" out of which the idea of right and wrong was elaborated. But quite as little as the savage did he think of extending the application of the principle beyond the bounds of his own race.

The laws with which he gave expression to his ethical conceptions applied, of necessity, to his own people alone.

The gods with which his imagination peopled the world were local in habitat, devoted to the interests of his race only, and at enmity with the gods of rival peoples.

As between nation and nation, the only prin-

ciple of ethics that ever occurred to him, was that might makes right.

Civilized man for a long time advanced but slowly upon this view of international morality. No Egyptian or Babylonian or Hebrew or Greek or Roman ever hesitated to attack a weaker nation on the ground that it would be wrong to do so. And few indeed are the instances in which even a modern nation has judged an international question on any other basis than that of self-interest.

It was not till toward the close of the nineteenth century that an International Peace Conference gave tangible witness that the idea of fellowship of nations was finding recognition; and in the most recent period history has recorded the first instance of a powerful nation vanquishing a weaker one without attempting to exact at least an "indemnifying" tribute.

But the citizen of the future, if the auguries of the present prove true, will be able to apply principles of right and wrong without reference to national boundaries.

He will understand that the interests of the entire family are, in the last analysis, common interests.

The census through which the attempts to estimate "the greatest good of the greatest number" must include, not his own nation merely, but the remotest member of the human race. On this universal basis must be founded that absolute standard of ethics which will determine the relations of Cosmopolite man with his fellows.

When this idea is attained, mankind will again represent a single family, as it did in the day when our primeval ancestor first entered on the

pathway of progress; but it will be a family whose habitat has been extended from the narrow glade of some tropical forest to the utmost habitable confines of the globe.

Each member of this family will be permitted to enjoy the greatest amount of liberty consistent with the like liberty of every other member; but the interests of the few will everywhere be recognized as subservient to the interests of the many, and such recognition of mutual interests will establish the practical criterion for the interpretation of international affairs.

But such an extension of the altruistic principle by no means presupposes the elimination of egoistic impulses—of individualism.

On the contrary, we must suppose that man at the highest stages of culture will be, even as was the savage, a seeker after the greatest attainable degree of comfort for the least necessary expenditure of energy. The pursuit of this ideal has been from first to last the ultimate impelling force in nature urging man forward. The only change has been a change in the interpretation of the ideal; an altered estimate as to what manner of things are most worth the purchase-price of toil and self-denial.

That the things most worth the having can not, generally speaking, be secured without such toil and self-denial, is a lesson that began to be inculcated while man was a savage, and that has never ceased to be reiterated generation after generation. It is the final test of progressive civilization that a given effort shall produce a larger and larger modicum of average individual comfort.

That is why the great inventions that have increased men's efficiency as a worker have been the necessary prerequisites to racial progress.

Stated otherwise that is why the industrial factor is everywhere the most powerful factor in civilization; and why the economic interpretation is the most searching interpretation of history at its every stage.

It is the basal fact that progress implies increased average working efficiency—a growing ratio between average effort and average achievement—that gives sure warrant for such a prognostication as has just been attempted concerning the future industrial unification of our race. The efforts of civilized man provide him, on the average, with a marvelous range of comforts, as contrasted with those that rewarded the most strenuous efforts of savage or barbarian, to whom present-day necessaries would have been undreamed luxuries. But the ideal ratio between effort and result has by no means been achieved; nor will have been until the inventive brain of man has provided a civilization in which a far higher percentage of citizens will find the life-vocations to which they are best adapted by nature, and in which, therefore, the efforts of the average worker may be directed with such vigor, enthusiasm, and interest as can alone make for true efficiency; a civilization adjusted to such an economic balance that the average man may live in reasonable comfort without heart-breaking strain, and yet accumulate a sufficient surplus to insure ease and serenity for his declining days.

Such, seemingly, should be the normal goal of progressive civilization.

Doubtless mankind in advancing toward that goal will institute many changes that could by no possibility be foretold; but (to summarize the views just presented) it seems a safe augury from present-day conditions and tendencies that the important lines of progress will include: (1) the organic betterment of the race through wise application of the laws of heredity; (2) the lessening of international jealousies and the consequent minimizing of the appalling drain upon communal resources that attends a military régime; and (3) an ever-increasing movement toward the industrial and economic unification of the world.

LOOKING FORWARD

All this, be it understood, implies no prophecy as to the incluson of mankind under one government or even under a world-wide confederation of nations, in the political sense.

Such an ideal, whether or not it be ultimately attainable, lies too far without the range of present probabilities to be suggested here as a supposable achievement of the ethnic era on which we are entering.

All that is here intended is to suggest that mankind in the near future will still more clearly recognize the truth, first definitely conceived in our own era, that restrictions upon the social, commercial, and intellectual intercourse of peoples occupying different regions of the globe must, in the nature of the case, act as barriers against the progress of civilization; that contrariwise, the human family can hope to maintain a high pitch of virility, a receptiveness to new ideas, and a genius for putting new projects into execution,

somewhat in proportion as it gives free and unhampered opportunity for the physical, intellectual, and industrial commingling of the races.

When these seemingly clear lessons from the history of human development are acted upon, a part at least of the appalling waste that attends our present economic system will be avoided.

Industries will flourish in their natural environment, and not behind the expensive barriers of "protective" tariffs.

The friction of labor will be minimized, and the efficiency of the individual laborer magnified, through increased specialization made possible by more fully organized industrial cooperation.

Individual competition—the healthful stimulus of fair and wholesome rivalry—will not cease, nor is it desirable that it should. But the average amount of freedom permitted every member of the race will be larger, the average amount of happiness attained by each member greater, than was ever possible at any antecedent stage of human development. This we may not doubt, since otherwise the entire scheme of evolution would betoken failure or retrogression; whereas no lesson is more surely taught by a wide survey of history than that the ever-varying aspects of civilization, viewed in the large from age to age, betoken actual and unequivocal progress.

CIVILIZATION AND PROGRESS

That in reality man has steadily progressed, in the sense of gaining greater average freedom and greater average happiness, even within the historical period, will hardly be denied by any one who attentively considers the historical records.

It is sometimes alleged, to be sure, that the gap between the average morality of to-day and that of the time of the Pharaohs is not a wide one. But we have just seen that it is really significant, especially when we reflect that the time involved in the entire historical period is relatively short. No really radical transformation could be expected in a mere hundred generations.

But, on the other hand, the aspects of practical civilization may be revolutionized—when the way is prepared for it by educational evolution—in a few generations, as in nineteenth century Europe, or even in a single generation, as in the case of Japan of to-day. Indeed it is probable that the final focalization of forces that permitted a conspicuous forward impulse took place rather suddenly in each of the great ethnic transformation periods of the past.

In other words it is entirely consistent with the theory of evolution to assume that there are long static periods; that evolution is not smoothly progressive; and that there may occur a seemingly sudden efflorescence of tendencies long in preparation,—a new application of long-familiar principles changing the aspect of the entire social structure.

It is in this way that the extraordinary changes of recent decades are to be interpreted.

And there is augury of great things for the near future in the fact of such relatively rapid progress in the recent past. Moreover it seems a natural result of the cumulative effects of revolutionary changes—each cause, as Spencer pointed out, having a multiplicity of effects, and each effect becoming in turn a cause—that progress

should be more and more rapid as the evolving organism becomes more complex.

It is argued, with much show of reason, that each successive ethnic period, in man's progress from savagery to civilization, was shorter than the one that preceded it, so that later periods involved only centuries where the earlier ones had compassed millenniums. There is justification, then, for the expectation that the new ethnic era on which mankind is seemingly just entering may progress toward the goal of its ideals more rapidly than a study of the changes that have taken place within the historical period might otherwise lead one to predict.

PRESENT AND FUTURE

But whether the new goal of Cosmopolitanism, Rationality, and International Helpfulness be approached swiftly or tardily, there can be little doubt that the generation which achieves it will look back upon the era of "higher civilization" in which humanity exists to-day, with much the same feelings with which we ourselves are accustomed to contemplate long-vanished eras of barbarism. The word "civilization," as applied, let us say, to the nineteenth century epoch, will doubtless then convey some such idea of crudity, of narrowness of view, of intellectual and moral undevelopment, as the word "barbarism" conveys to our minds to-day.

Such, in the nature of the case, must be the attitude of each progressive generation toward its predecessors. The butterfly can not be expected to admire the chrysalis-shell out of which it has emerged.

There is some consolation, however, in the reflection that all the potentialities of the future are of necessity embodied, however obscure their manifestation, in the civilization of our own time; and whoever is disposed to cavil at the "irrationalities" of existing society may advantageously reflect that these are what time and opportunity have made them, and can be altered for the better only through the cumulative effect of minute changes in the right direction. Seeing such changes in operation everywhere about him, the philosophical observer will realize with satisfaction that the civilization of our era, superstitious, egoistic, and militant tho it be, is at the same time virile, stimulative, far-searching, and fecund with promise of a greater future.

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